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FULL-SCALE IMPLEMENTATION OF THE SODIUM SULFIDE/ FERROUS SULFATE TREATMENT PROCESS

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In Phase I, jar and dynamic testing showed that the sodium sulfide/ferrous sulfate process was a viable method for reducing hexavalent chromium and removing heavy metals from the Tinker AFB industrial wastewater with a significant decrease in sludge production and treatment costs. In Phase II pilot-plant field verification studies were conducted to evaluate the chemical and physical parameters of the chromium reduction process, the precipitation and clarification process, and the activated sludge system. Sludge production was evaluated and compared to the sulfuric acid/sulfur dioxide/lime process. The impact of and procedure for change-over to the sodium sulfide/ferrous sulfate process were also investigated. In this phase, Phase III, the process was implemented full-scale at Tinker AFB. This report includes change-over strategy to prevent violation of discharge limitations, and an operation and maintenance manual for the system. Data for 3 months of operation is provided.

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EXECUTIVE SUMMARY

The overall purpose of this program is to reduce the hazardous wastes in the effluent of the Tinker AFB industrial waste treatment plant (IWTP). The wastes, produced by electroplating, aircraft engine and parts cleaning, and paint stripping, comprise primarily chromium, nickel, copper, cadmium, lead, and zinc. Conventional waste treatment methods produce large quantities of sludge, which requires special handling and burial at hazardous waste landfills.

Phase I of this program showed the feasibility of the sodium sulfide/ferrous sulfate process in reducing the hexavalent chromium, precipitating the metals, and decreasing sludge production. Laboratory studies were conducted, using jar and dynamic tests, on electroplating rinsewater and industrial wastewater with a significant decrease in sludge production and treatment costs. In Phase II, pilot-plant field verification studies were conducted to evaluate the chemical and physical parameters of the sodium sulfide/ferrous sulfate process, the precipitation and clarification process, and the activated sludge system. The chemical requirements for the process are:

Sodium Sulfide	2 mg/L S^{-2} per 1 mg/L Cr^{+6}
Ferrous Sulfate	1.5 mg/L Fe^{+2} per 1 mg/L Cr^{+6}
Betz 1195 Cationic Polymer	20 mg/L
Betz 1120 Anionic Polymer	0.5 mg/L
pH Mixer-2	7.2 - 7.5

Phase III of the project was implementation of the sodium sulfide/ferrous sulfate process in the Tinker AFB Industrial Waste Treatment Plant. Implementation included installation of the equipment required for the process. The equipment installed included an influent pH control, sodium sulfide, ferrous sulfate, sulfuric acid, cationic and anionic polymer feed systems, a streaming current detector, a turbidimeter, a continuous hexavalent chromium monitor, and a sludge recirculation system for the solids contact clarifier. An operation and maintenance manual was prepared and the process was changed over to the sodium sulfide/ferrous sulfate process.

Startup and operation occurred with minimal problems. Tinker AFB personnel have been receptive to the new process and prefer it over the old process. The metal content and the chemical oxygen demand in the effluent of the Industrial Waste Treatment Plant have remained well below National Pollutant Discharge Elimination System requirements.

Cost comparisons of the sodium sulfide/ferrous sulfate process and the sulfuric acid/sulfur dioxide/lime process shows a chemical treatment sludge removal savings of $370,000/yr without reclamation of the water. Since the sodium sulfide/ferrous sulfate process does not require softening of the water for reclamation for the industrial processes, the cost savings is $655,000/yr if the water is reclaimed. These cost savings are based on Tinker AFB data from operation with the sulfuric acid/sulfur dioxide/lime process from January 1 through June 30, 1988, projected to one year (141,913,000 gallons of wastewater with 4454 pounds of hexavalent chromium were treated in the 6 months), and from chemical usage with the sodium sulfide/ferrous sulfate process during July and August. The sludge data are based on operating data for both processes and filtered-weight data for the sulfide sludge.

PREFACE

This report was prepared by Idaho National Engineering Laboratory, EG&G Idaho, Inc., P.O. Box 1625 Idaho Falls, Idaho 83415 under Contract Number DE-AC07-76ID01570 for the Air Force Engineering and Services Center (AFESC), Tyndall Air Force Base, Florida 32403-6001. Mr Charles J. Carpenter was the Government technical program manager. This report summarizes work accomplished between 1 November 1987 and 30 September 1988.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical publication has been reviewed and is approved for publication.

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SECTION I

INTRODUCTION

A. OBJECTIVE

Air Force electroplating facilities range from operations of three to four baths to those covering 40,000 square feet of floor space (Reference 1). Principal contaminants in the wastewaters are chromium, nickel, copper, cadmium, lead, and zinc. Engine cleaning and paint stripping processes also release heavy metals to the industrial wastewater. These wastes pose environmental hazards and must be treated to reduce the hexavalent chromium and precipitate the metals. Conventional treatment methods produce large quantities of sludge, which must be treated as hazardous waste and buried at approved landfills.

The purpose of this program was to determine the feasibility of using sodium sulfide and ferrous sulfate to reduce the hexavalent chromium, precipitate the metals, and decrease sludge production. Phase I investigated the use of this process in laboratory studies (jar tests and dynamic tests) on distilled water and Tinker Air Force Base (AFB) electroplating rinsewater and industrial wastewater. Phase II determined the feasibility of the process in a pilot-scale field verification study using the influent of the Tinker AFB Industrial Waste Treatment Plant (IWTP). Phase III was full-scale implementation of the process at the Tinker AFB IWTP.

B. BACKGROUND

The electroplating process includes degreasing, alkaline cleaning, electrocleaning, acidizing, and electrochemical deposition of the protective metal. The process produces metals and chemical solutions that are carried into the rinse water, which must be treated at the Industrial Waste Treatment Plant (IWTP) at the Air Logistics Centers (ALCs) (Reference 2). Other wastewaters are produced from engine-cleaning and paint-stripping processes. The wastewaters contain hexavalent chromium, chromium, nickel, copper, cadmium, lead, and zinc, as well as complexing and chelating agents such as tartrates, phosphates, cyanides, ethylenediaminetetraacetic acid (EDTA), ammonia, and other contaminants such as phenols, oils, and greases. The wastewater must be treated to remove these contaminants. For the metals of concern, the effluent from the IWTP at Tinker AFB, Oklahoma, must meet the limits listed in Table 1 to comply with the National Pollutant Discharge Elimination System (NPDES) Permit (Reference 3).

TABLE 1. TINKER AFB NPDES PERMIT REQUIREMENTS (Reference 3)

Constituent	Concentration (mg/L)
Cadmium, total	0.03
Chromium, total	1.0
Chromium, hexavalent	0.1
Copper, total	0.1
Lead, total	0.1
Nickel, total	1.0
Zinc, total	1.0

In 1980, regulations issued by the Environmental Protection Agency (EPA), classified metal-bearing sludges generated at the Air Logistics Center (ALC) IWTP as hazardous waste. The sludges, therefore, require costly disposal ($220/ton) in hazardous waste landfills and special handling (Reference 2). Disposal costs can be reduced by decreasing the amount of sludge produced.

The common treatments for the industrial wastewater are oil and grease separation, destruction of cyanides, reduction of the hexavalent chromium, precipitation of the metal hydroxides, biological treatment for organic removal, and sludge disposal (Reference 4). Conventional treatment of the mixed metal wastewater consists of reducing the hexavalent chromium at acidic conditions (pH 2 to 3) with sodium sulfite, sodium bisulfite, or sulfur dioxide and precipitating the trivalent chromium and other metals at alkaline pH using either lime or caustic. The treatment chemicals used at Tinker AFB are sulfuric acid, sulfur dioxide, and lime. This treatment method requires both acidic and alkaline controls, large quantities of chemicals, and produces a large amount of sludge.

Reduction of hexavalent chromium with sulfide in the presence of ferrous ion produces less sludge than the conventional acidic sulfur dioxide/lime treatment process. Earlier Air Force studies have shown that the sodium sulfide/ferrous sulfate process can effectively reduce hexavalent chromium with removal of mixed metals at neutral and alkaline conditions. The report on Phase I of this program contains an extensive literature review describing and chemistry of the hexavalent chromium reduction and metal precipitation (Reference 5).

Phase I of this program was performed to validate that the sodium sulfide/ferrous sulfate treatment method would reduce hexavalent chromium and remove heavy metals from electroplating and industrial wastewater with clarifier operation (Reference 5). This method was validated by a large number of jar tests to investigate the extent of this reaction as a function of a number of variables similar to those experienced in a typical waste treatment process such as the process used at Tinker AFB. Dynamic tests were also conducted to evaluate this method in a continuous operation mode. The sodium sulfide/ferrous sulfate process successfully reduced hexavalent chromium and removed total metal from electroplating waste and the Tinker AFB IWTP influent wastewater to below NPDES permit requirements. In addition, sludge production from the sulfuric acid/sulfur dioxide/lime process was compared to that of the sodium sulfide/ferrous sulfate process. The relative dry weight difference was one to twelve. (These samples were dried in an oven at 104°C for 24 hours.) The results of Phase I indicated that the sodium sulfide/ferrous sulfate process has significant potential for reducing both chemical and sludge disposal costs.

In Phase II, pilot-plant field verification studies were conducted to evaluate the chemical and physical parameters of the sodium sulfide/ferrous sulfate process, the precipitation and clarification process, and the activated sludge system (Reference 6). A pilot-scale field verification unit was constructed at the Tinker AFB IWTP. The unit was designed as a scaled-down model of the Tinker AFB unit with its chromium reduction mixer basins, solids contact clarifier, activated sludge basin, and final clarifier. The retention time and flow velocity were designed to simulate 500,000 to 1,500,000 gallons/day through the Tinker AFB Unit.

The process was optimized for sodium sulfide, ferrous sulfate, cationic polymer, anionic polymer, and pH requirements. The chemical requirements are listed in Table 2. The pH of the influent had no effect on the process as long as it was maintained above 7.2. At lower pHs, hydrogen sulfide gas forms. The optimum pH after ferrous ion addition to Mixer Basin 2 was 7.2 to 7.5.

TABLE 2. CHEMICAL REQUIREMENTS FOR THE SODIUM SULFIDE/FERROUS SULFATE PROCESS.

Sodium Sulfide	2 mg/L S^{-2} per 1 mg/L Cr^{+6}
Ferrous Sulfate	1.5 mg/L Fe^{+2} per 1 mg/L Cr^{+6}
Betz 1195 Cationic Polymer	20 mg/L
Betz 1120 Anionic Polymer	0.5 mg/L
pH, Mixer Basin 2	7.2 - 7.5

The solids contact clarifier at the Tinker AFB IWTP was designed by Walker Process Corporation. (A schematic of the solids contact clarifier is shown in Figure 1.) The effluent of Mixer Basin 3 flows to the center well of the solids contact clarifier, where it is mixed with an anionic polymer by an external sludge recirculation flow. A flash mixer in the center well pulls the sludge from the bottom of the clarifier for an internal sludge recirculation. The sludge is mixed in this center well as a seed, or aid, for flocculation. The mixture flows from the top of the

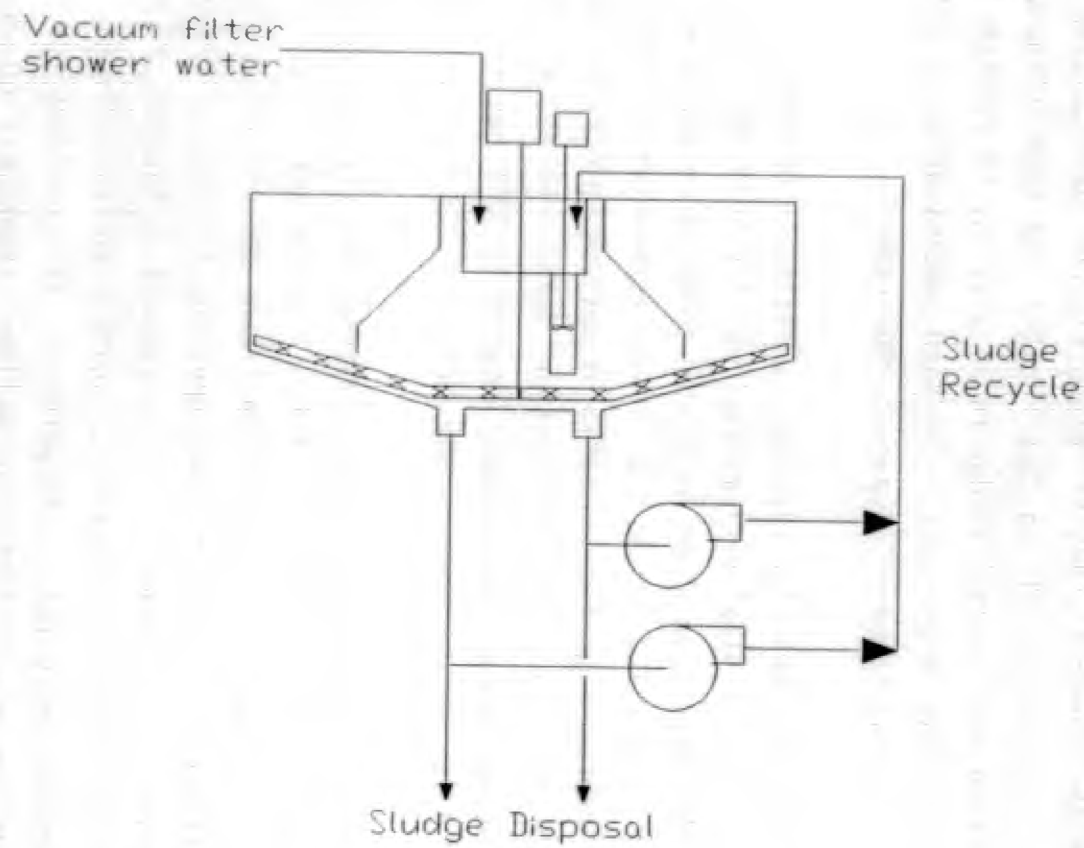


Figure 1. Schematic of the Solids Contact Clarifier.

center well to an intermediate settling ring, or skirt. In normal operation of the solids contact clarifier, the sludge depth is kept below this skirt. However, with the sodium sulfide/ferrous sulfate process, it was found that a sludge depth greater than the bottom of the skirt was required such that the effluent could flow under the intermediate skirt, through the sludge bed, up through an outer ring, and over the weir of the solids contact clarifier. In this manner, the treated wastewater is filtered through the sludge blanket to remove the fine particulates. External sludge recirculation (10 to 20 percent of the IWTP influent) is required, along with the internal sludge recirculation, to maintain 80 to 90 percent solids in the center cell. The high concentration of solids is required to remove metal below NPDES permit requirements.

After the solids contact clarifier was operating at optimum conditions, the effect of ethylenediaminetetraacetic acid (50 mg/L), orthophosphate (100 mg/L) and mixed metals on chromium reduction was determined. With chemical feeds at the levels represented in Table 2, and with the solids contact clarifier operated at optimum conditions, these additives had no effect on chromium reduction, metal removal, or activated sludge. Influent wastewater temperatures from 41 to 95°F had no effect, nor did flows proportional to 500,000 and 2,000,000 gal/day.

Sludge production from the sodium sulfide/ferrous sulfate process was determined by filtering the sludge collected from the solids contact clarifier through a laboratory vacuum-drum filter and measuring the volume. In addition, the pilot unit was operated with the acid/sulfur dioxide/lime process for sludge production comparison between the two methods. With the sodium sulfide/ferrous sulfate process, sludge production decreased approximately 90 percent. The procedure for implementing the sodium sulfide/ferrous sulfate process was determined.

Cost comparison of the sodium sulfide/ferrous sulfate process and the sulfuric acid/sulfur dioxide/lime process showed a potential savings of $317,781/yr for sludge removal with the sodium sulfide/ferrous sulfate process. These savings were based on the use of dry chemicals for the sodium sulfide/ferrous sulfate process and the treatment of 11,789 pounds of hexavalent chromium in 284,406,312 gallons of industrial wastewater in 1986 and the disposal of 2100 tons of metal sludge at $168/ton.

C. SCOPE

The purpose of Phase III of this program was to implement the sodium sulfide/ferrous sulfate process at the Tinker AFB IWTP. The instruments and equipment necessary for the implementation were installed, and an Operation and Maintenance (O&M) manual was prepared. The O&M manual is included as Appendix A. The process was implemented and monitored for 30 days after implementation. This report describes the equipment installed, the results of implementation and a cost comparison of the sodium sulfide/ferrous sulfate process with the sulfuric acid/sulfur dioxide/lime.

The report is in two parts: (a) the Phase III report itself, and (b) Appendix A, the Operation and Maintenance Manual, which, although written for the IWTP at Tinker AFB, is also appropriate for use at other Air Force wastewater treatment plants that use the same process. For ease of use, the Operation and Maintenance Manual has its own Table of Contents.

SECTION II

EQUIPMENT DESCRIPTION AND PROCESS IMPLEMENTATION

A. EQUIPMENT DESCRIPTION

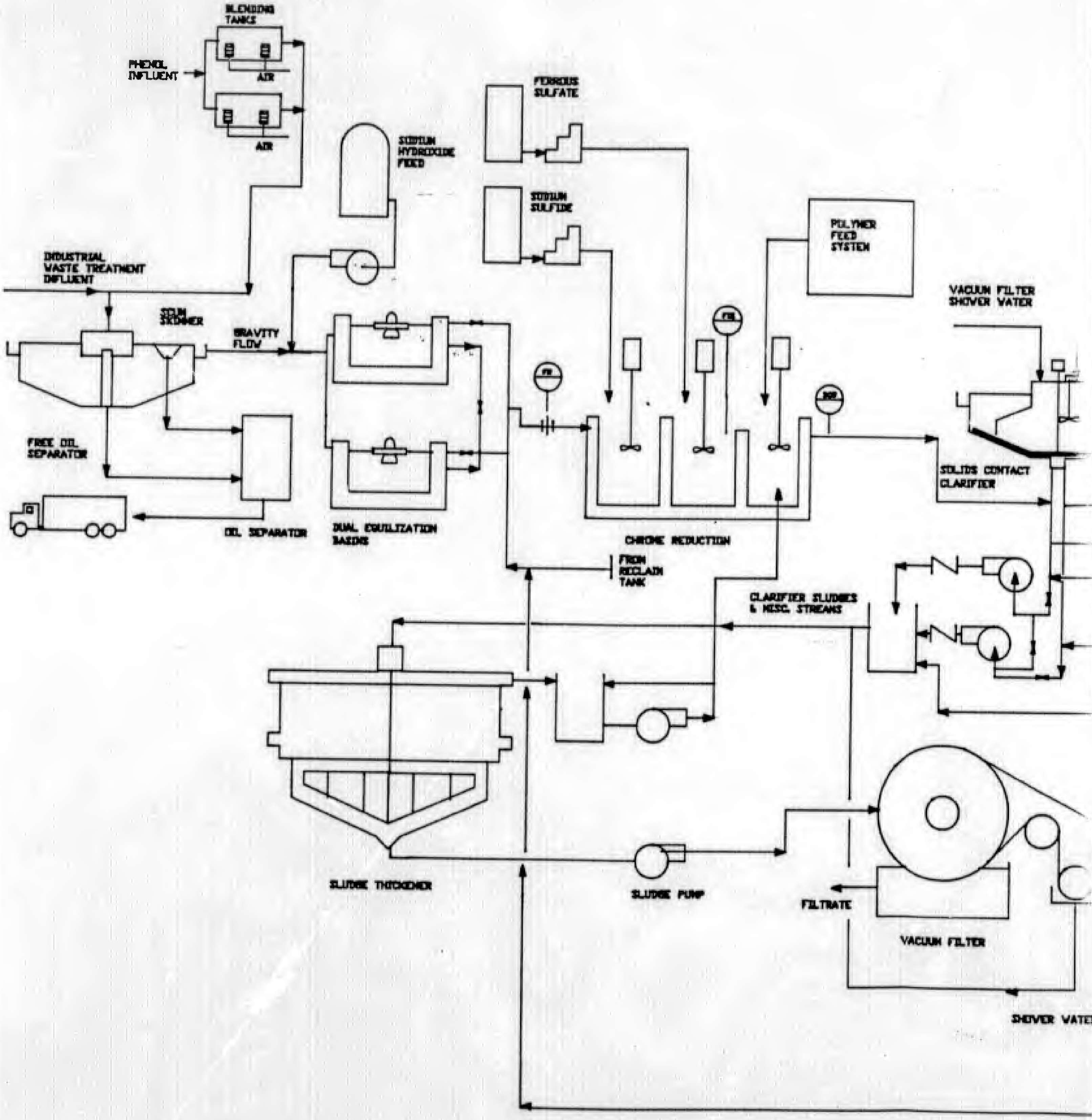
A block diagram of the Tinker AFB IWTP is shown in Figure 2. The major components of the process are the blending tanks, the oil separator, the equalization tanks, Mixer Basins 1, 2, and 3, the solids contact clarifier, the activated sludge basin and clarifiers, the chlorine contact unit, the final filters, the sludge thickener, and the sludge filter. The equipment installed for implementation of the sodium sulfide/ferrous sulfate process is outlined in Figure 2. The equipment and its purpose are listed briefly below.

- At the effluent of the oil separator, a caustic feed system was installed to control the influent's pH to greater than 7. (The pH must be greater than 7 before sulfide is added to prevent offgassing of toxic hydrogen sulfide gas.) The caustic feed is controlled by a pH meter and probe installed at the equalization tank inlet pipe. In the automatic mode, if the pH is below 7, the caustic pump will start pumping caustic to the oil separator effluent and will continue until the pH in the line is 7 or greater.

- A sodium sulfide feed system was installed at Mixer Basin 1.

- A ferrous sulfate feed system was installed at Mixer Basin 2.

- The sulfuric acid feed system was modified to feed concentrated sulfuric acid to Mixer Basin 2. The feed is controlled by a pH meter and probe located at Mixer Basin 2. A circular chart recorder in the control room records the pH as a function of time. The pH of this basin is controlled at pH 7.2 to 7.5.



BLENDING TANKS
PHENOL INFLUENT
AIR
AIR
SODIUM HYDROXIDE FEED
FERROUS SULFATE
SODIUM SULFIDE
POLYMER FEED SYSTEM
INDUSTRIAL WASTE TREATMENT INFLUENT
SCUM SKIMMER
GRAVITY FLOW
VACUUM FILTER SHOWER WATER
FREE OIL SEPARATOR
SOLIDS CONTACT CLARIFIER
OIL SEPARATOR
DUAL EQUILIZATION BASINS
CHROME REDUCTION
FROM RECLAIM TANK
CLARIFIER SLUDGES & MISC. STREAMS
SLUDGE THICKENER
SLUDGE PUMP
FILTRATE
VACUUM FILTER
SHOWER WATER

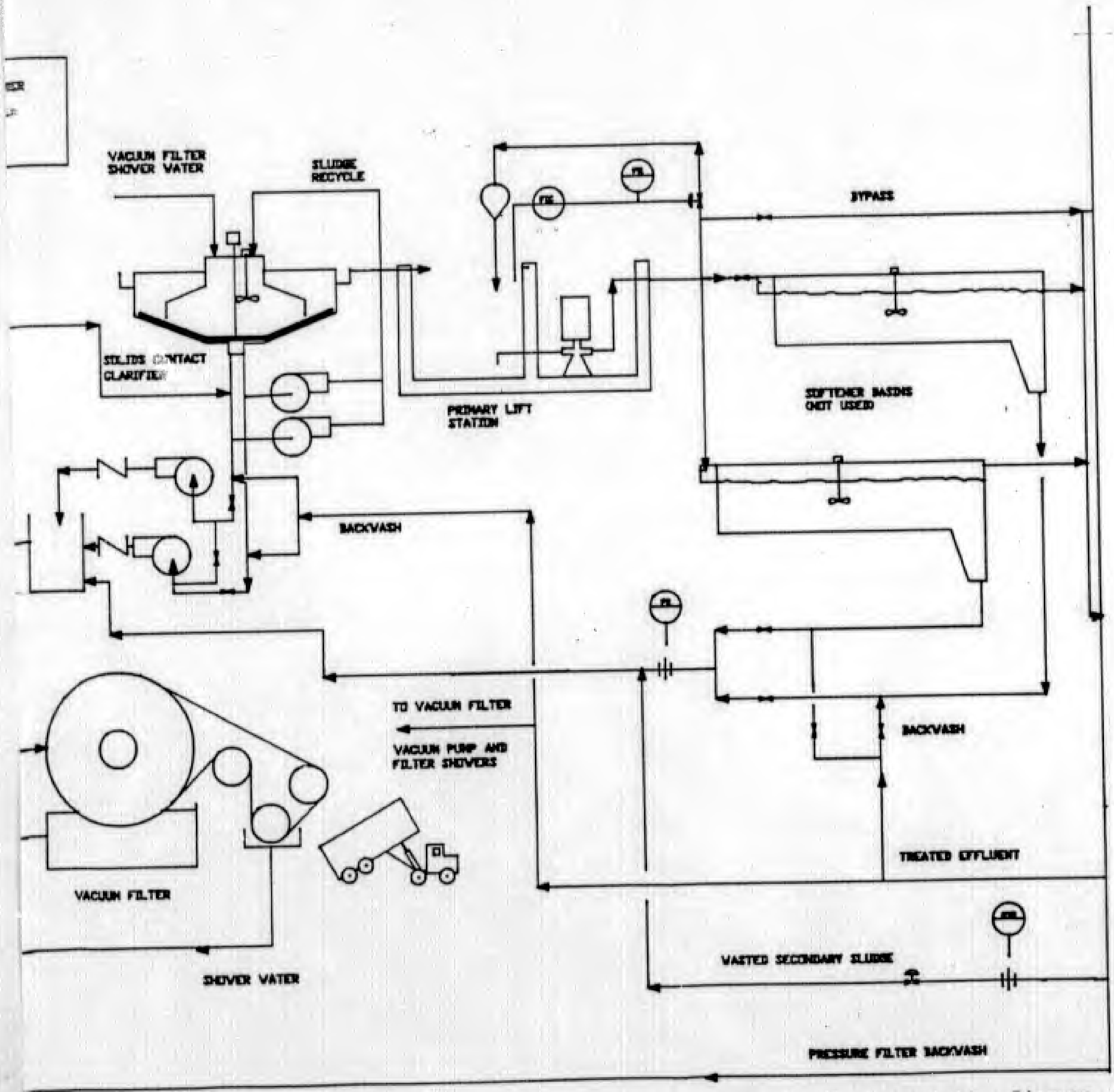


Figure 2. IWTP Flow/Instrumentation Diagram.

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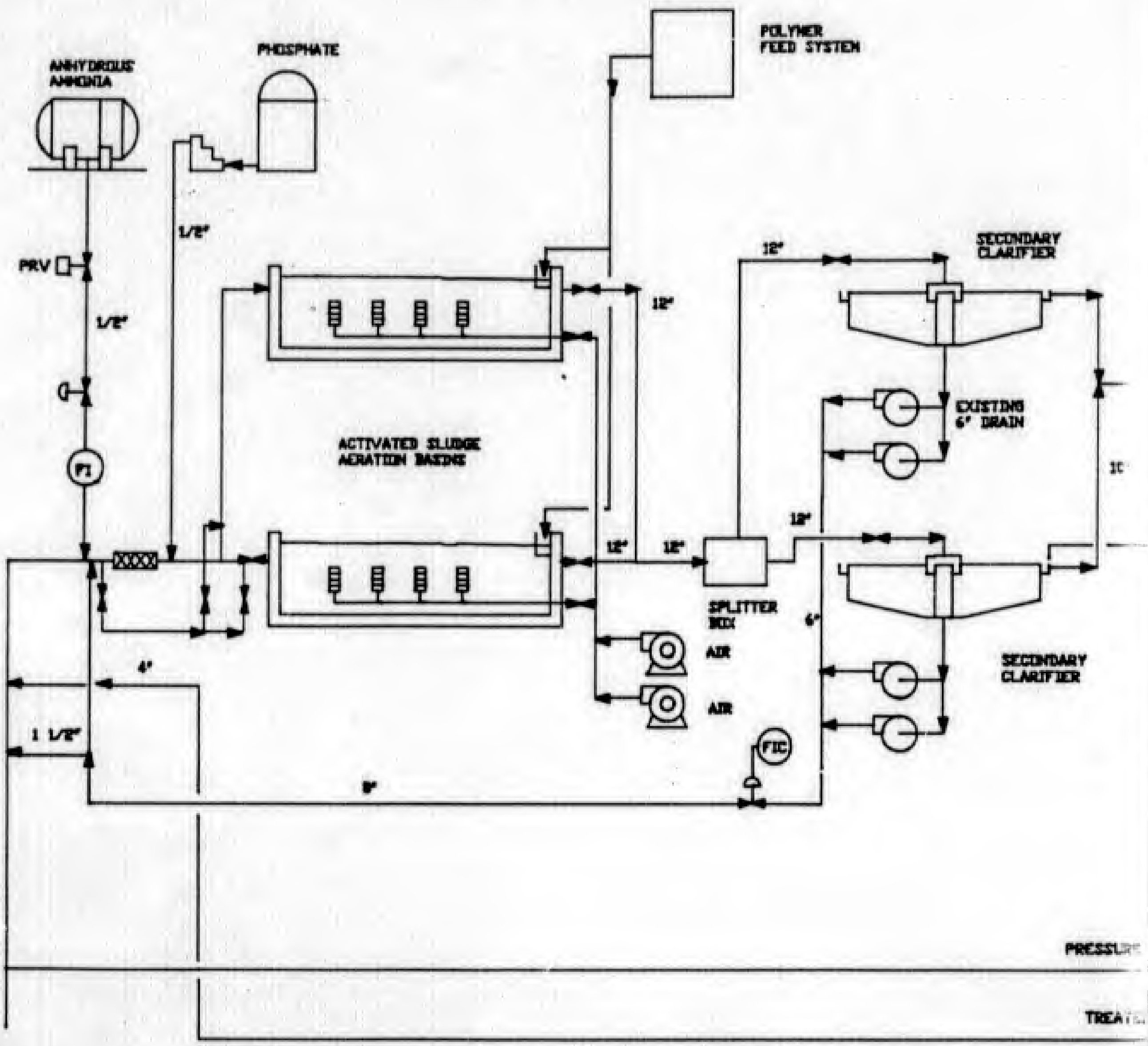
ANHYDROUS AMMONIA
PHOSPHATE
POLYMER FEED SYSTEM
PRV
1/2"
1/2"
PI
12"
12"
12"
12"
12"
SECONDARY CLARIFIER
EXISTING 6" DRAIN
ACTIVATED SLUDGE AERATION BASINS
SPLITTER BOX
6"
AIR
AIR
FIC
4"
1 1/2"
SECONDARY CLARIFIER

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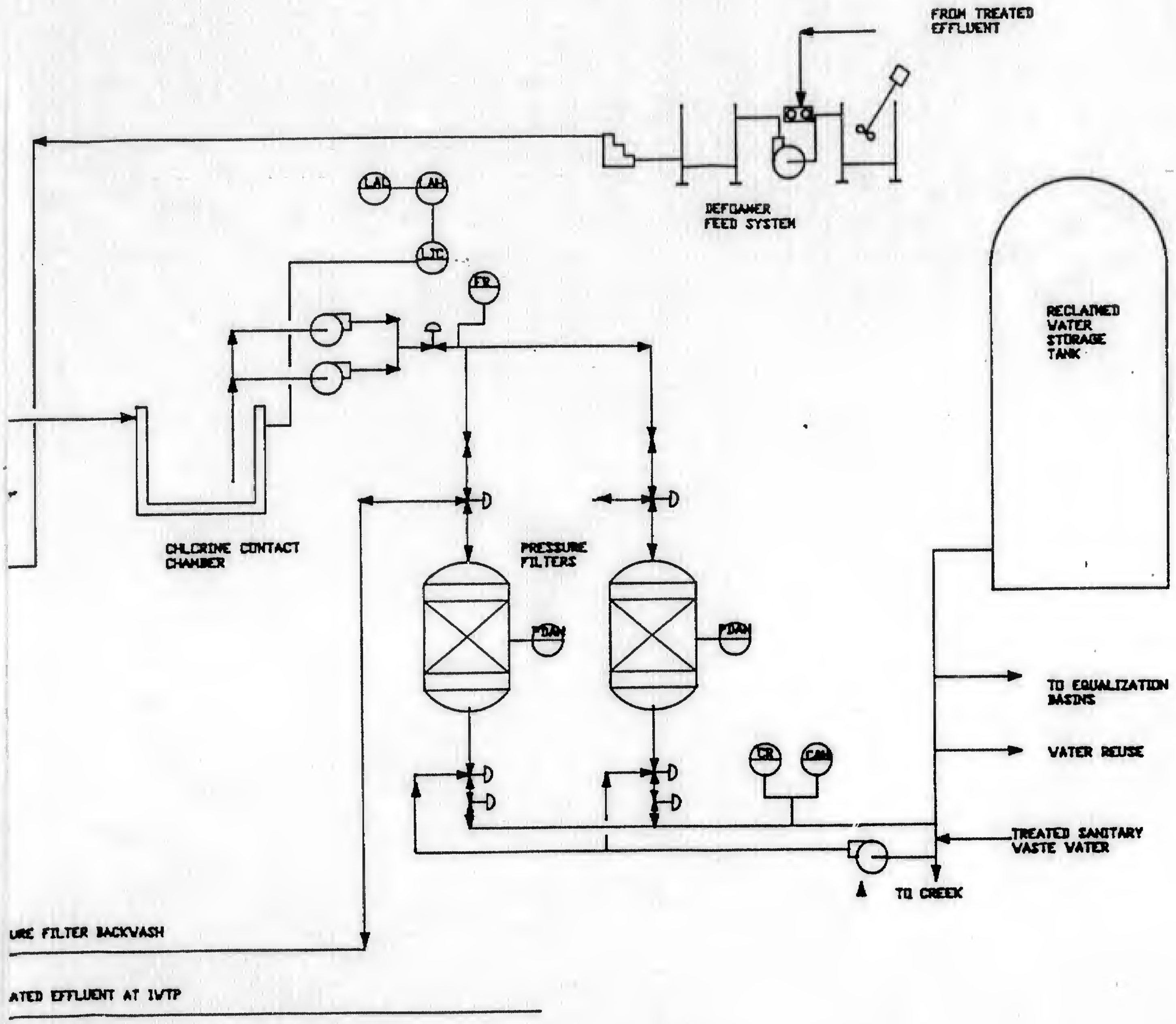

gure 2 (continued)

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- A feed system for the Betz 1195 cationic polymer was installed at Mixer Basin 3. The concentrated liquid polymer is diluted before feeding to the mixer basin. The diluted polymer feed is controlled to Mixer Basin 3 by a Milton Roy Streaming Current Detector, which was set to control the charge in the positive range at +2 units. The chart recorder in the control room monitors and records the streaming current.

- A feed system for the Betz 1120 anionic polymer was installed to feed the dilute polymer to the center mixing well of the solids contact clarifier.

- A HACH Chemical Company turbidimeter was installed for monitoring the turbidity of the solids contact clarifier's effluent as a function of time.

- A Scientific Instruments Continuous Flow Analyzer was installed for monitoring the hexavalent chromium at the effluent of the clarifier.

- Dual external sludge recirculation pumps were installed at the solids contact clarifier--each pump is rated at 180 gallons/minute. The pumps are equipped with a timer and may be operated in the manual or automatic mode. Sludge is recirculated from the bottom of the solids contact clarifier to the center mixing well where it is mixed with the influent from Mixer Basin 3 and the anionic polymer.

- A sludge depth monitor was installed in the solids contact clarifier. An alarm sounds in the control room when the sludge reaches the required depth (10 feet, for example) in the clarifier.

B. PROCESS IMPLEMENTATION

In the changeover of the process to the sodium sulfide/ferrous sulfate process, the external sludge recirculation is started first in the solids contact clarifier (Figure 1) at 10 to 20 percent of the plant influent flow, after which the polymer feed (Betz 1195 cationic polymer) is started to Mixer Basin 3. The feed is controlled by the streaming current detector to a streaming current reading of +1.0 to +2.0 units, which is approximately 20 milligrams/liter of Betz 1195, depending on what other specie is present in the wastewater. The Betz 1120 anionic polymer is fed to the center mixing well (Figure 1) of the solids contact clarifier at 0.5 milligrams/liter. The polymers are fed for approximately one week before starting the sodium sulfide and ferrous sulfate feed. The lime floc in the solids contact clarifier is light and fluffy, but the addition of the polymer causes the floc to compact, and the sludge depth decreases from greater than 7 feet (Figure 1) to 2 feet in the Tinker AFB SCC. Before starting the sodium sulfide and ferrous sulfate feed, it is desirable to allow the sludge depth to build to 7 feet. This allows the sludge blanket to act as a filter for the fine precipitate or floc produced.

After the sludge bed has been built with the sulfuric acid/sulfur dioxide/lime process with the polymer feeding and the external sludge recirculation, the ferrous sulfate feed is started to Mixer Basin 2 at six times the normally required ferrous concentration (6 times 1.5 mg/L Fe^{+2} per 1 mg/L Cr^{+6}). At the same time, the sulfuric acid and sulfur dioxide feed to Mixer Basin 1 is stopped and the pH of the basin allowed to increase to greater than 7.0. The increased ferrous concentration is required to ensure continued reduction of the hexavalent chromium while the pH in Mixer Basin 1 increases to a pH where the sodium sulfide can be added without hydrogen sulfide offgassing. This requires approximately one retention time of Mixer Basin 1 (approximately 20 to 30 minutes). When Mixer Basin 1 is at pH 7 or greater, the sodium sulfide feed is started at 2 mg/L S^{-2} per 1 mg/L Cr^{+6}. At the same time, sulfuric acid feed is started to Mixer Basin 2 to control the pH at 7.2 to 7.5. After approximately one retention time of Mixer Basin 1, the ferrous sulfate feed to Mixer Basin 2 is decreased to 1.5 mg/L Fe^{+2} per 1 mg/L Cr^{+6} and the lime feed to Mixer Basin 3 is stopped. The system is then operating in the normal mode for the sodium sulfide/ferrous sulfate process.

SECTION III

RESULTS

During the sodium sulfide/ferrous sulfate process startup, the hexavalent chromium concentration was monitored in Mixer Basin 2. It remained below the detection level during the entire startup period. The hexavalent chromium concentration at the effluent of the solids contact clarifier has remained below the detection level since startup of the sodium sulfide/ferrous sulfate process.

The suspended solids, turbidity, sludge depth, and flow during startup of the sludge recirculation and polymer feed are shown in Figures 3 and 4. During the initial polymer feed (before addition of sodium sulfide and ferrous sulfate), both the rake and the flash mixer quit working in the solids contact clarifier; however, when they were working, the sludge recirculation and the polymer addition resulted in a turbidity decrease in the solids contact clarifier effluent. Correlated with this was a decrease in the metal in the effluent (Figures 5 and 6). Even when the

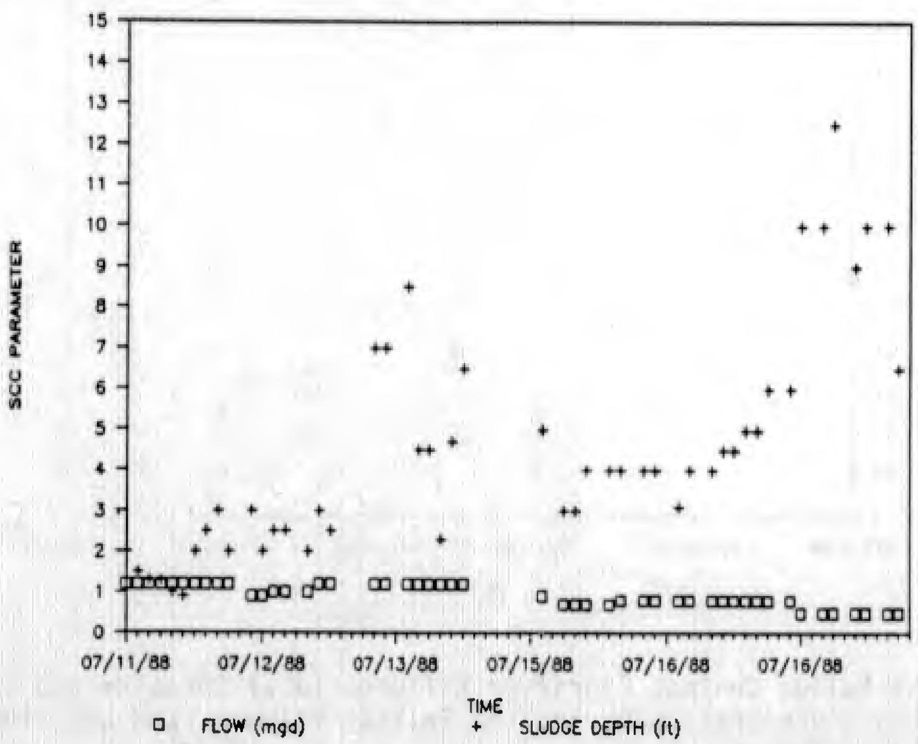

Figure 3. Plant Flow and Solids Contact Clarifier Sludge Depth During the Initial Polymer Feed and Sludge Recirculation.

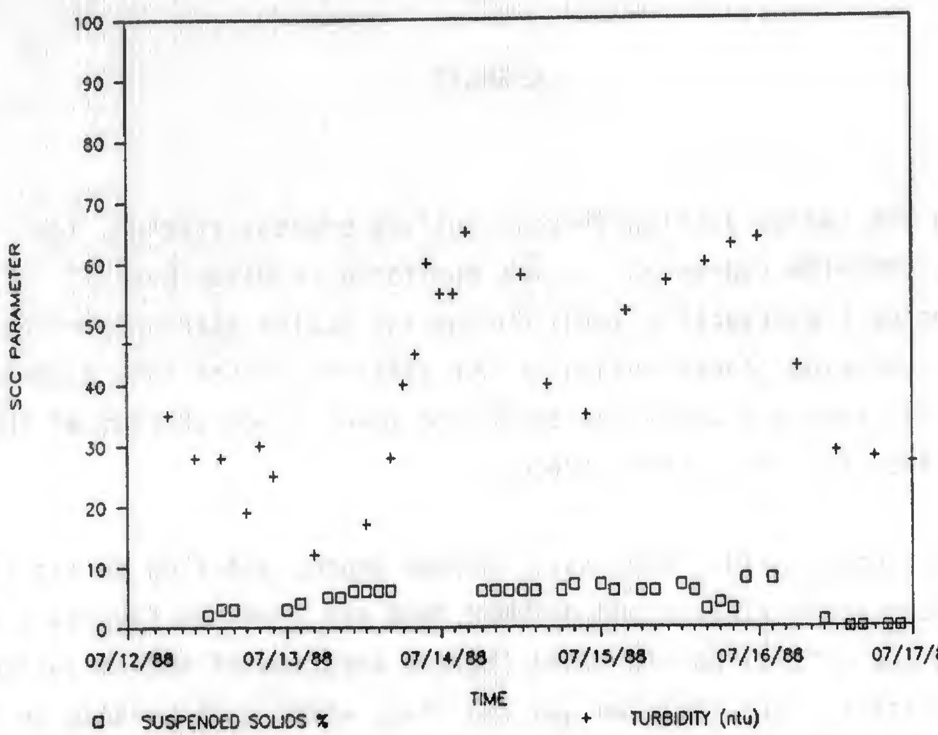

Figure 4. The Solids Contact Clarifier Suspended Solids and Turbidity During the Initial Polymer Feed and Sludge Recirculation.

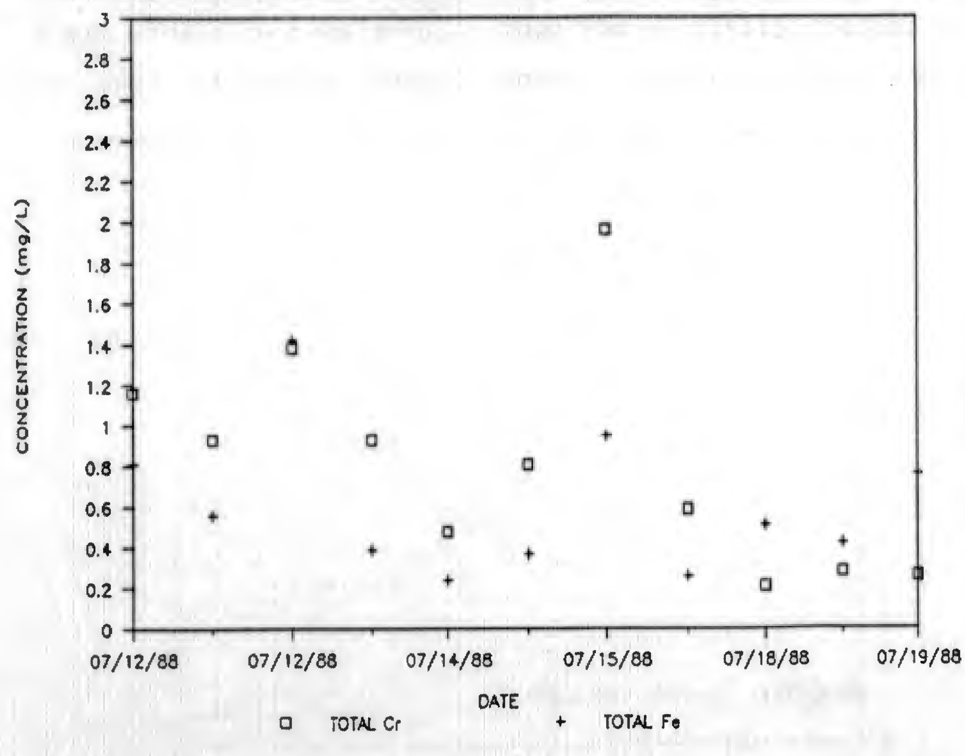

Figure 5. The Solids Contact Clarifier Effluent Total Chromium and Total Iron Concentration During the Initial Polymer Feed and Sludge Recirculation.

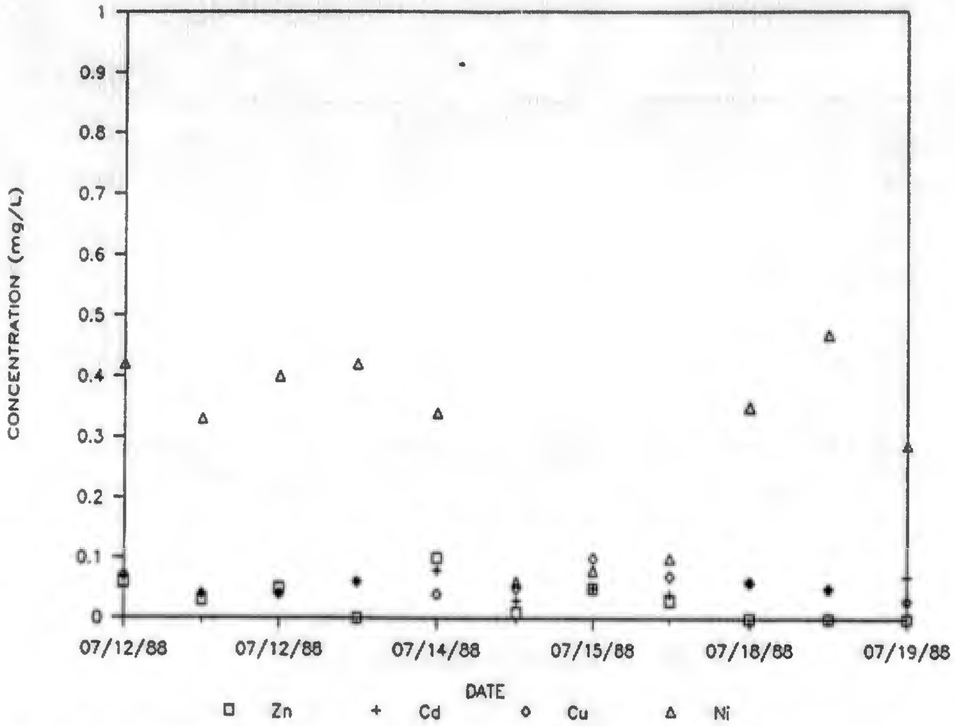

Figure 6. The Solids Contact Clarifier Effluent Zinc, Cadmium, Copper, and Nickel Concentration During the Initial Polymer Addition and Sludge Recirculation.

rake and flash mixer were not working, a decrease was noted in the effluent metals of the solids contact clarifier.

During initial sludge recirculation startup, the sludge recirculation pumps could not be run continuously without increasing the solids contact clarifier effluent pH to 12, with potential upset to the activated sludge system, due to excess lime in the settled sludge. Therefore, one pump was operated for 3 minutes and turned off for 15 minutes while the lime feed to Mixer Basin 3 was decreased. The pump was then set to run full time. Turning the pump on full increased the sludge depth from 5 to 12.5 feet and decreased the turbidity from 60 to 29 ntu (nephophilic turbidity units) over 10 hours.

Figures 7 and 8, show the solids contact clarifier parameters during the first few days of startup of the sodium sulfide and ferrous sulfate feed, and Figures 9, 10, and 11 show the solids contact clarifier effluent metals and chemical oxygen demand (COD), as well as the COD at the chlorine contact unit. An increase in turbidity and metal carryover

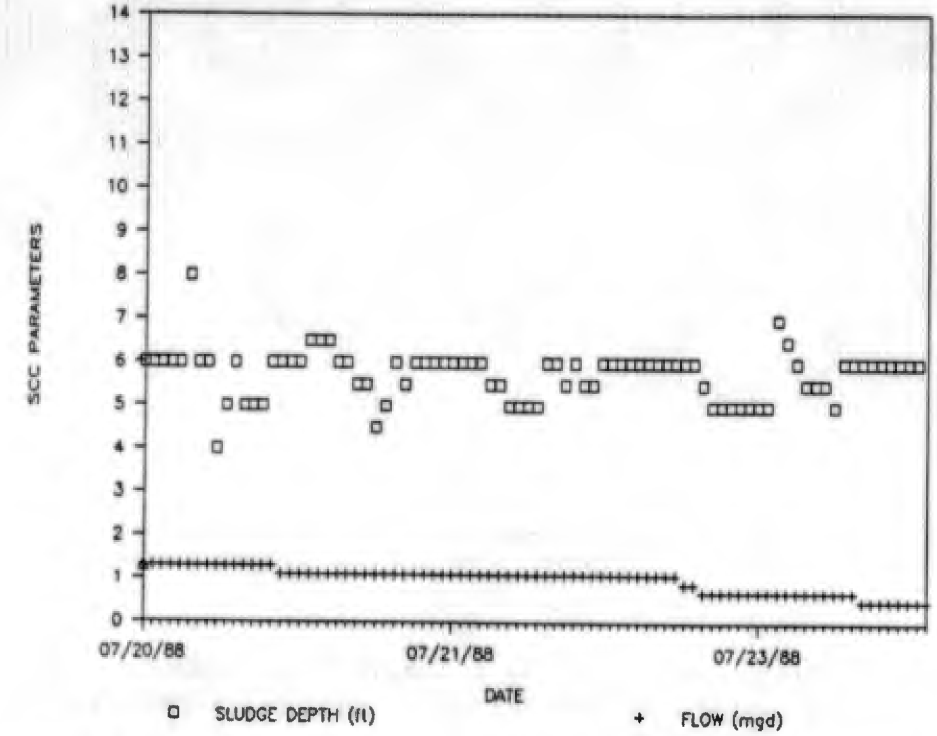

Figure 7. The Flow and Sludge Depth of the Solids Contact Clarifier During Process Startup.

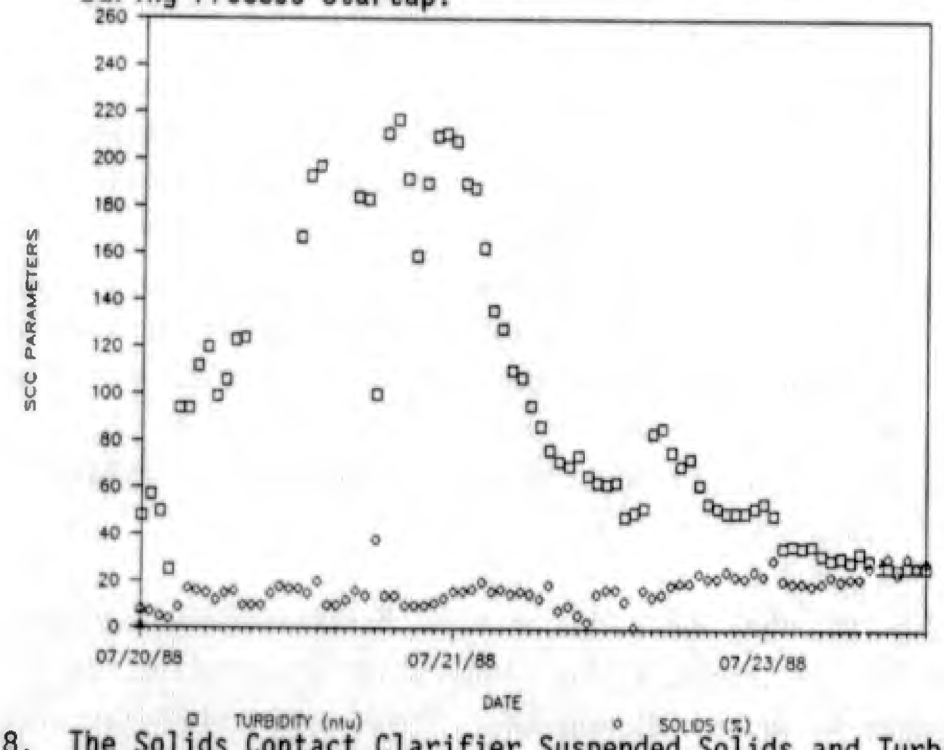

Figure 8. The Solids Contact Clarifier Suspended Solids and Turbidity During Process Startup.

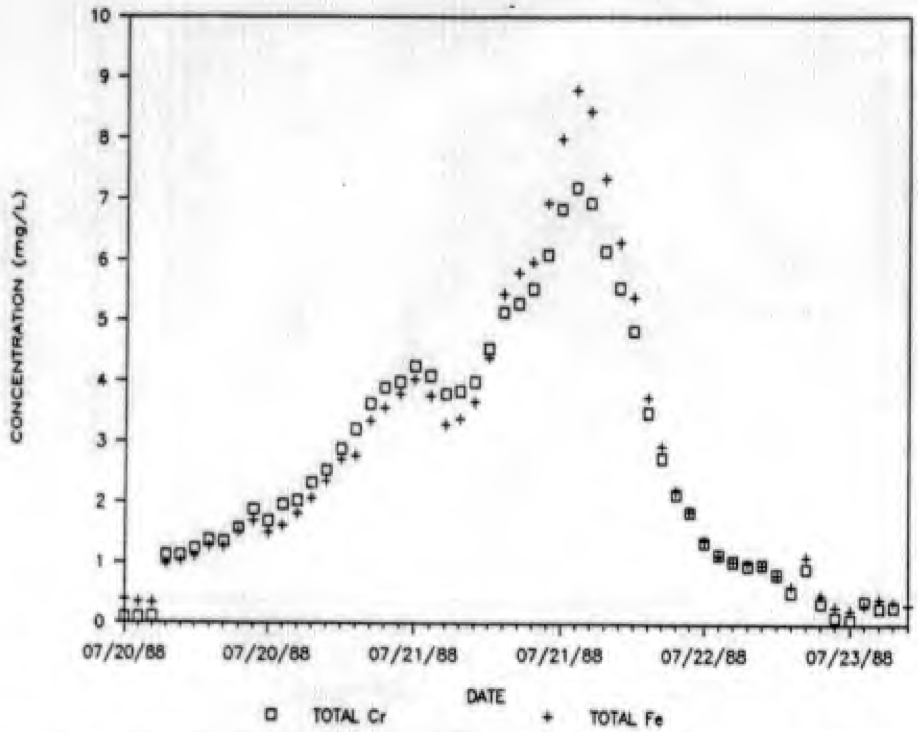

Figure 9. The Solids Contact Clarifier Effluent Total Chromium and Total Iron Concentration During Process Startup.

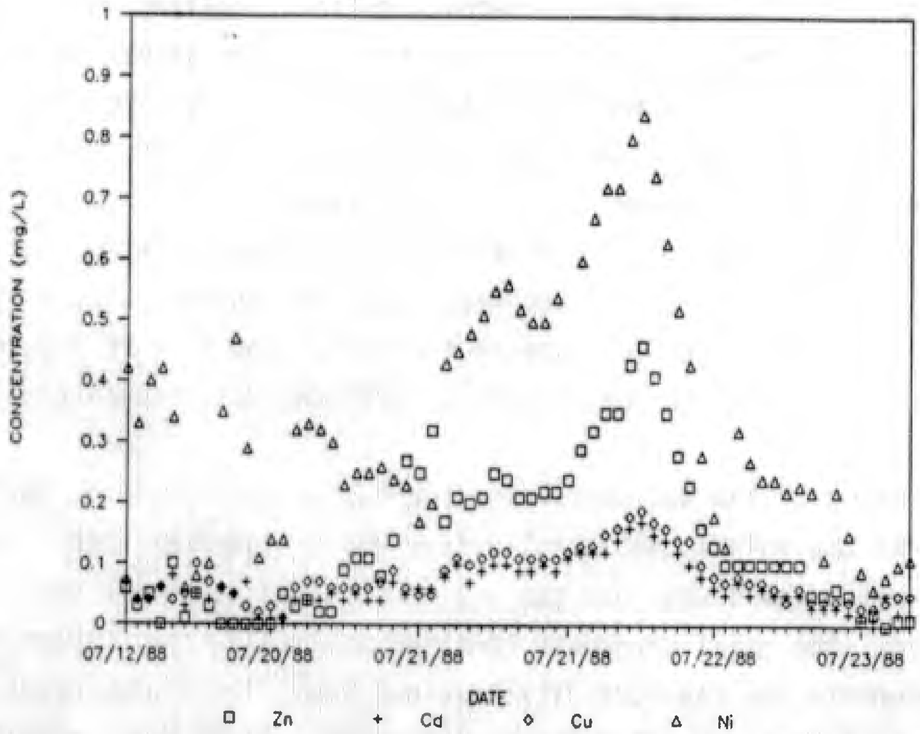

Figure 10. The Solids Contact Clarifier Effluent Zinc, Cadmium, Copper, and Nickel Concentration During Process Startup.

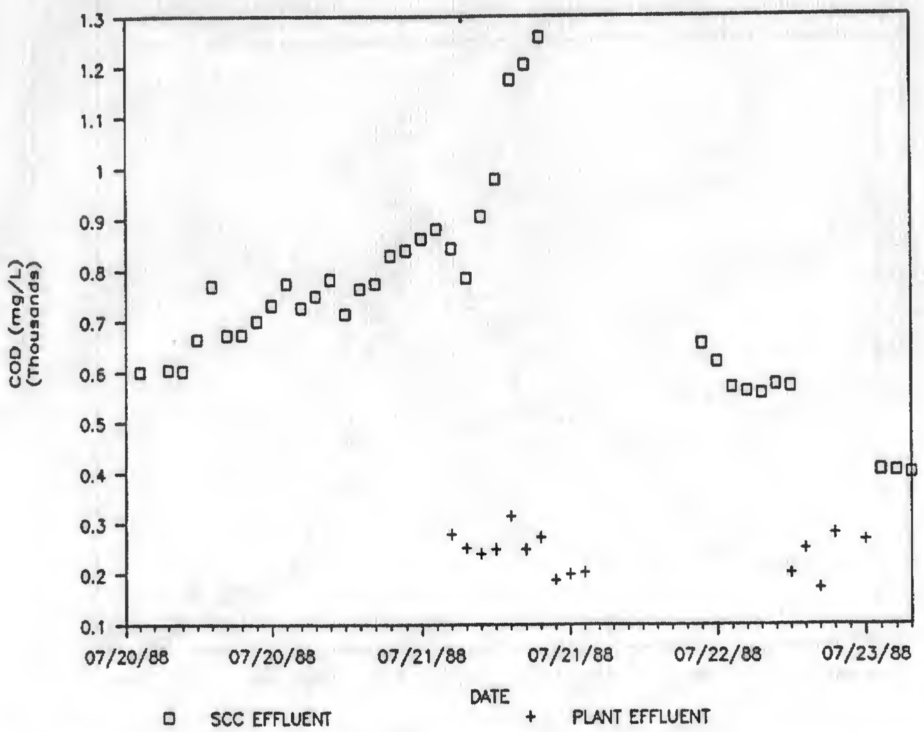

Figure 11. The Solids Contact Clarifier and Chlorine Contact Unit Effluent Chemical Oxygen Demand (COD) During Process Startup.

during startup of the sodium sulfide/ferrous sulfate resulted from incorrect setting of the Betz 1195 cationic feed and the streaming current detector at Mixer Basin 3. When the control point of the streaming current detector was set at +2 units and the concentration of the Betz 1195 feed solution increased, turbidity decreased to 10 ntu and the metal in the solids contact clarifier effluent decreased. Later, an upset in the flow of the Betz 1195 dilution water resulted in decreased polymer feed to Mixer Basin 3 and an increase in turbidity from 8 to 20 ntu, but no increase in the solids contact clarifier effluent metal concentrations.

During startup of the sodium sulfide/ferrous sulfate process, the sludge depth in the solids contact clarifier was not greater than 7 feet, the depth at which the sludge bed can act as a filter to remove the fines. However, the metal carryover remained well below the current NPDES permit requirements and the turbidity remained low. The sludge depth increased to 12.5 feet after 2 weeks of operation. At 12 feet, sludge carries over from the solids contact clarifier due to movement of the rake at the bottom of the clarifier. It was determined that the optimum sludge depth for operation of the sodium sulfide/ferrous sulfate process was 10 feet of sludge in the solids contact clarifier.

Several parameters were monitored in the effluent of the solids contact clarifier and at the chlorine contact unit of the IWTP during the first 30 days of operation of the sodium sulfide/ferrous sulfate process. These steady-state data are shown in Figures 12-17.

During the changeover to the sodium sulfide/ferrous sulfate process, several biological parameters on the activated system were monitored. In general, there was no indication of negative impact to the activated sludge basin during the changeover and during the days following implementation of the new process. Conditions seemed to improve after the 5th day as indicated by improved respiration rates (Figure 18) and increased ATP (adenosine triphosphate) levels (Figure 19). Also, greater diversity of biological activity in the activated sludge was apparent in

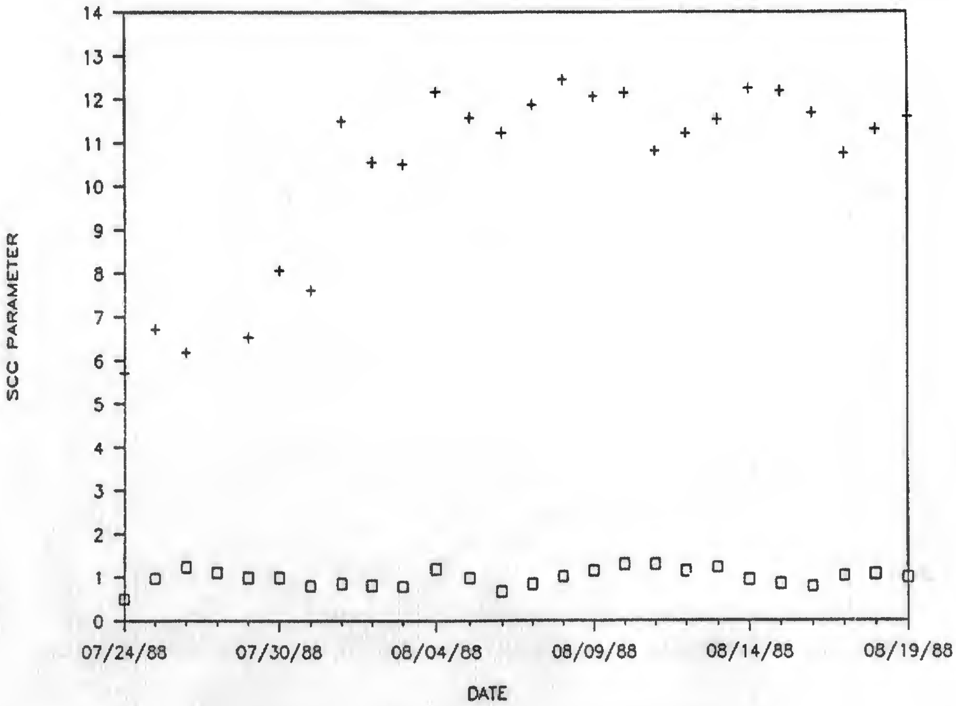

Figure 12. Sludge Depth and Flow of the Solids Contact Clarifier During the Sodium Sulfide/Ferrous Sulfate Steady-State Operation.

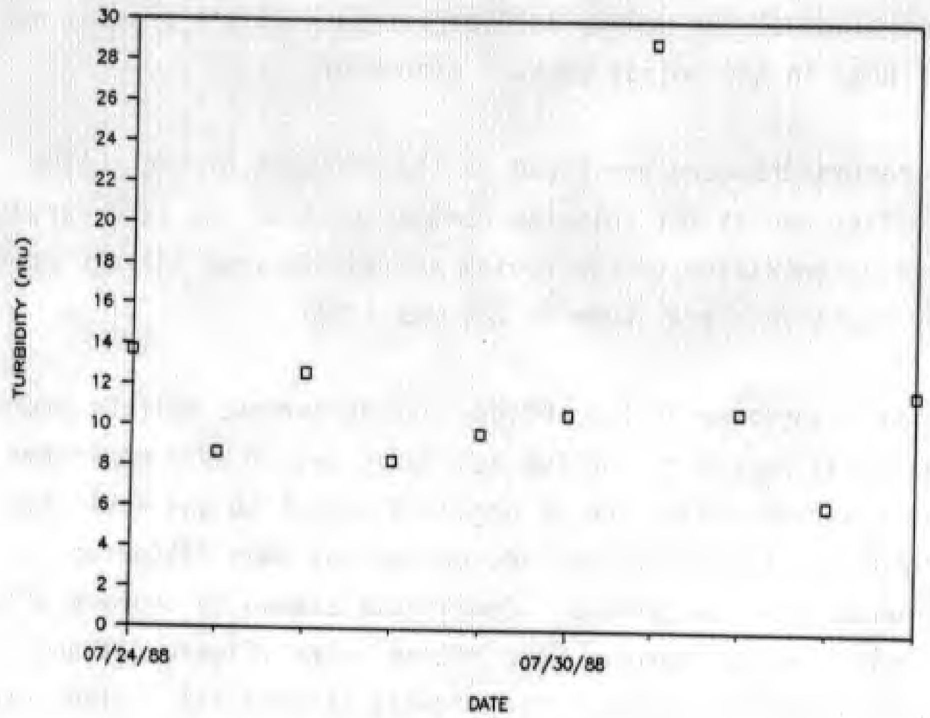

Figure 13. Turbidity of the Solids Contact Clarifier During the Sodium Sulfide/Ferrous Sulfate Steady-State Operation.

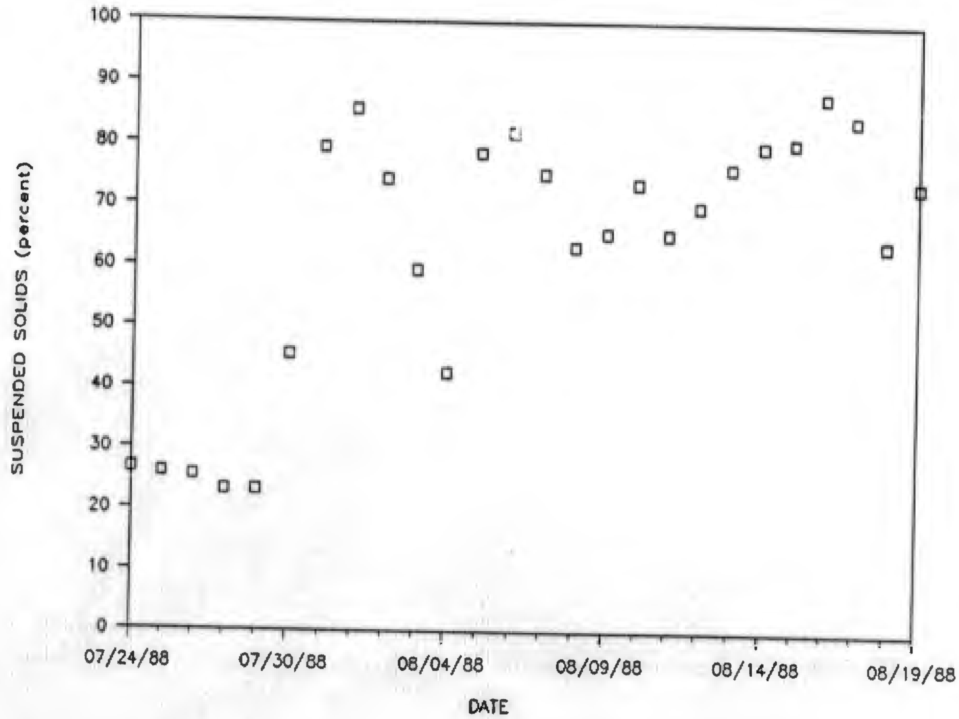

Figure 14. Suspended Solids of the Solids Contact Clarifier During the Sodium Sulfide/Ferrous Sulfate Steady-State Operation.

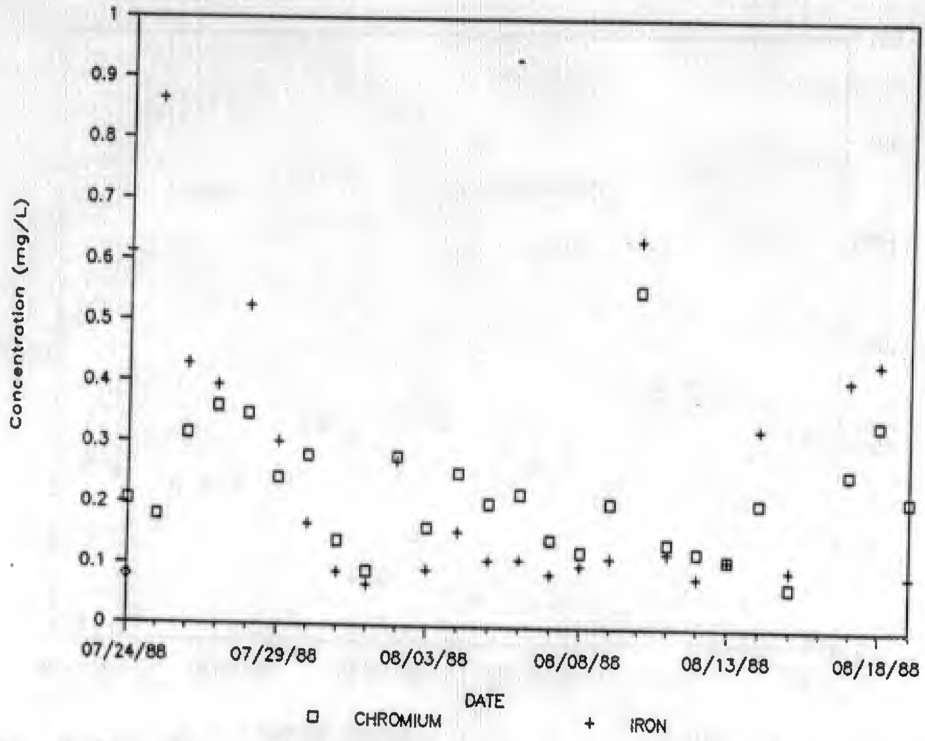

Figure 15. Solids Contact Clarifier Effluent Total Chromium and Total Iron During the Sodium Sulfide/Ferrous Sulfate Steady-State Operation.

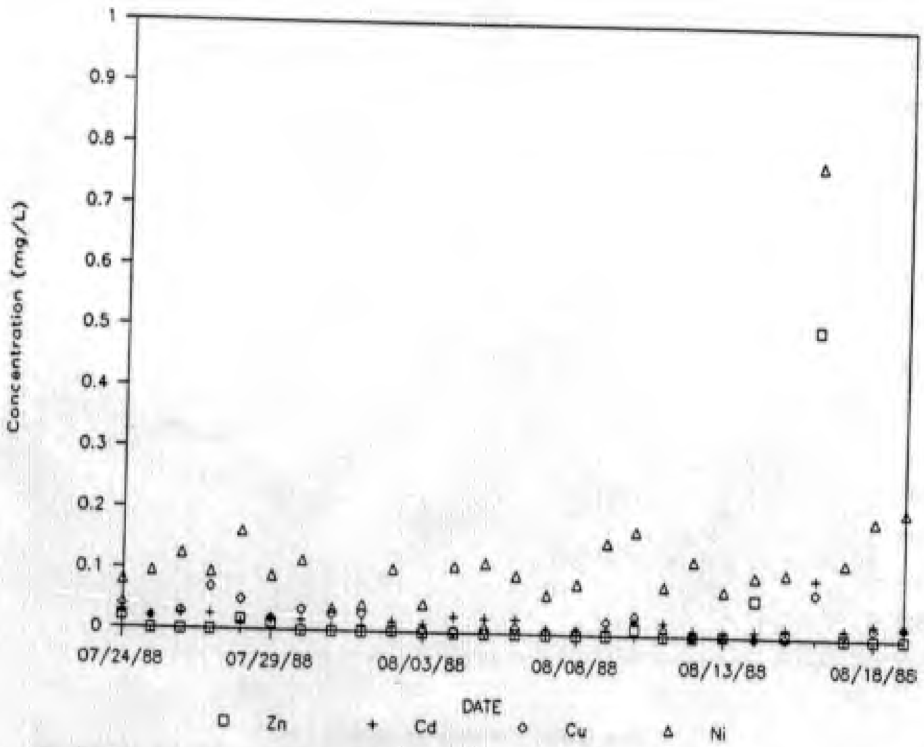

Figure 16. Solids Contact Clarifier Effluent Zinc, Cadmium, Copper, and Nickel During the Sodium Sulfide/Ferrous Sulfate Steady-State Operation.

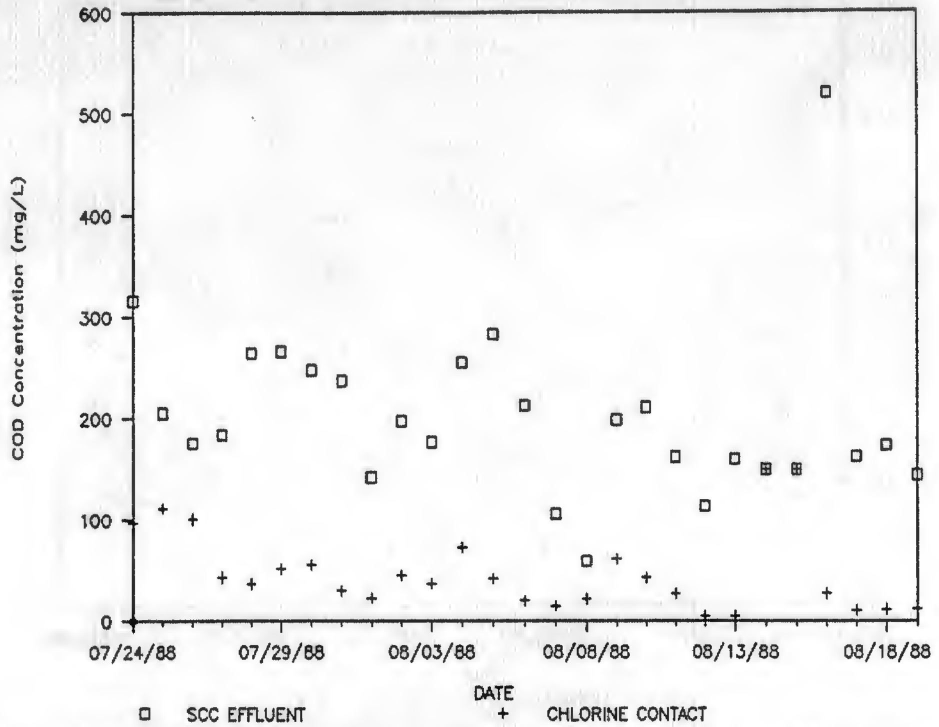

Figure 17. Solids Contact Clarifier and the Chlorine Contact Unit Effluent Chemical Oxygen Demand (COD) During the Sodium Sulfide/Ferrous Sulfate Steady-State Operation.

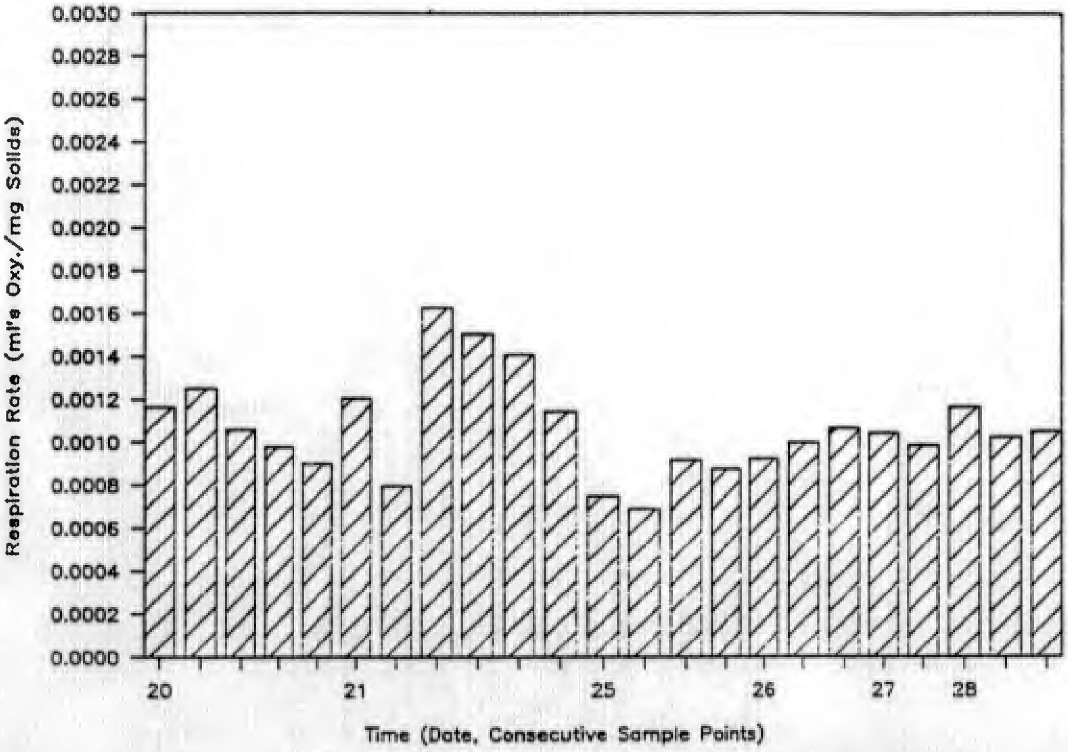

Figure 18. Activated Sludge System Respirometry During Process Changeover.

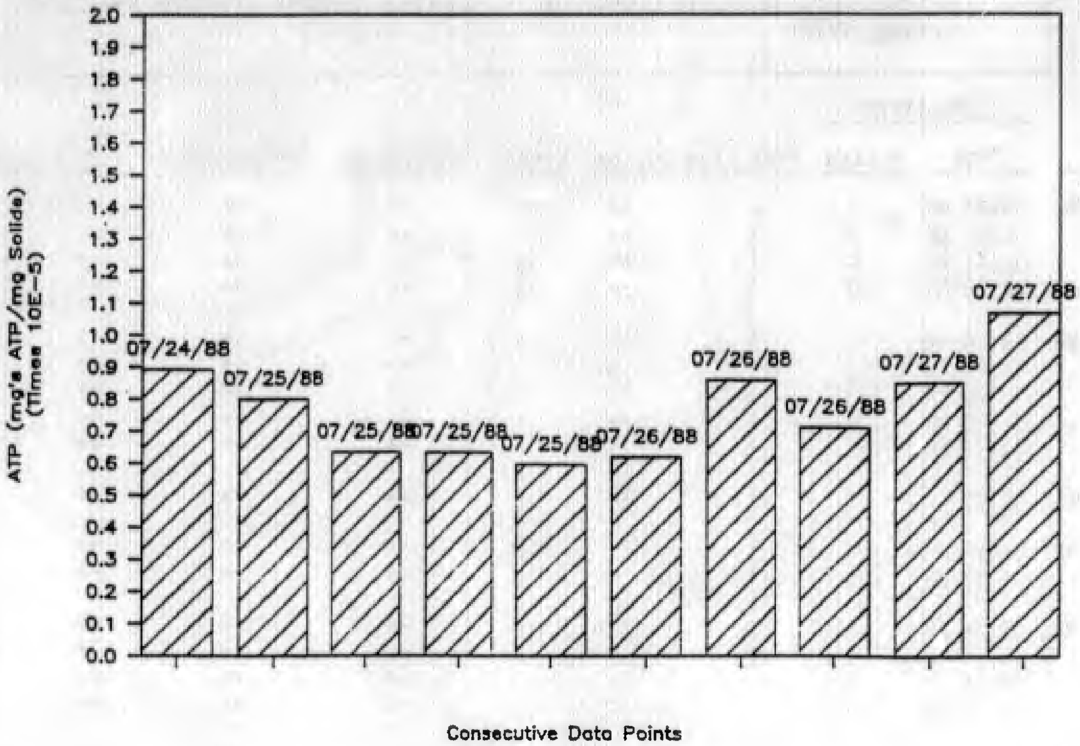

Figure 19. Activated Sludge System ATP During Process Changeover.

the daily microscopic observations of the sludge material (Table 3). Results of the observations during implementation supported the conclusions from Phase I testing.

TABLE 3. MICROSCOPE OBSERVATIONS OF ACTIVATED SLUDGE DURING PROCESS CHANGEOVER.

Date	Time	Rotifers Active	Rotifers Nonactive	Cysts	Fungal	Vorticella	Filamentous	Motile Cells	Other
07/21/88	10:42 AM	7	4	**	**	**	**	**	**
	11:51 AM	7	3	**	1	**	**	**	**
	01:11 PM	5	1	**	4	**	**	**	**
	04:20 PM	10	3	**	4	**	**	**	**
07/22/88	10:36 AM	9	3	11	4	**	**	**	2
	11:00 AM	13	3	9	2	**	**	**	1
	12:00 PM	7	4	19	5	**	**	**	2
	01:00 PM	8	5	15	1	**	**	**	--
	02:19 PM	7	3	17	3	**	**	**	1
07/23/88	08:25 AM	2	1	16	3	**	**	**	1
07/24/88	09:29 AM	4	1	10	3	**	**	**	5
	01:20 PM	5	1	10	3	**	**	**	5
07/25/88	09:06 AM	5	0	16	2	**	**	**	2
	12:15 PM	9	0	15	4	**	**	**	4
	02:15 PM	9	0	15	2	**	**	**	2
	04:05 PM	10	1	17	4	**	**	**	2
07/26/88	09:02 AM	6	1	12	0	**	**	**	10
	11:58 AM	8	0	13	4	1	**	**	8
	03:02 PM	22	0	8	4	4	**	**	14
07/27/88	09:05 AM	3	2	14	0	17	4	23	2
	11:57 AM	10	3	14	1	21	0	40	1
07/28/88	09:00 AM	17	4	25	3	30	0	29	6
	12:02 PM	21	5	27	2	31	0	53	5
	03:05 PM	24	5	26	1	39	3	31	4

**Parameter not initially distinguished.

SECTION IV
CONCLUSIONS

The sodium sulfide/ferrous sulfate process has been operational in the Tinker AFB IWTP since August 1988. Minimal problems were experienced during startup, initial operation, and while adapting to full-scale operation. For the most part, the Tinker AFB personnel have been receptive to the process and prefer the new operation over the sulfuric acid/sulfur dioxide/lime process. During startup and the following days of operation, the metals and COD at the IWTP effluent did not exceed the NPDES permit requirements.

During the startup period, a few upsets occurred such as errors in the addition of the polymers, sulfide or ferrous feed pump backflow, and allowing excess sludge to build in the solids contact clarifier. These upsets did not affect the operation of the activated sludge systems.

A cost comparison of the sodium sulfide/ferrous sulfate process with the sulfuric acid/sulfur dioxide/lime process was completed using the IWTP plant data for the first 6 months of 1988, the cost of the sulfuric acid, sulfur dioxide and lime, the sludge produced during that period and the chemical cost and usage for the first month of operation of the sodium sulfide/ferrous sulfate process. The cost was projected over one year. The cost comparison is given in Table 4. As shown in the table, the savings over one year is $370,000/yr without reclamation of the water. If the water is reclaimed for reuse in the industrial processes, the cost savings is $655,000/yr, since the sodium sulfide/ferrous sulfate process does not require softening of the water for reclamation. The sludge produced by the process is 180 tons/year compared to the 1880 tons produced by the sulfuric acid/sulfur dioxide/lime process.

NOTE: Sludge production is based on the sludge wasted from the SCC during the first month of operation of the sodium sulfide/ferrous sulfate process. The sludge volume was recorded, and the filtered weight of the sludge was determined by filtering a volume of the wasted sludge with a laboratory Buchner funnel and determining the wet filter weight. A true

TABLE 4. COST COMPARISON OF THE SODIUM SULFIDE/FERROUS SULFATE PROCESS TO THE SULFURIC ACID/SULFUR DIOXIDE/LIME PROCESS

Treatment Cost for Sulfuric Acid Lime System	
Sulfur Dioxide (3000-lb cylinders 74 cylinders @ 460/CY)	\$ 34,040
Sulfuric Acid (1,800,000 lb @ \$0.04/lb)	\$ 72,000
Calcium Hydroxide (650 tons @ \$66/ton	\$ 42,900
Sludge Disposal Cost (1,886 tons at \$220/ton)	\$414,920
Total Costs Without Water Softening	\$563,860
Softening to 150 mg/L CaCO3	
Soda Ash (828 tons @ \$124/ton)	\$102,672
Sludge Disposal (828 tons @ \$220/ton	\$182,160
Total Softening Costs	\$284,832
Total Treatment Costs	[a]\$848,692
Treatment Cost for Sodium Sulfide/Ferrous System	
Sulfide Solution (124,000 mg/L S-2) (10.4 lb/gal) (179,482 lb @ \$0.17/lb)	\$ 30,512
Ferrous Sulfate Solution (70,000 mg/L Fe+2) (10.7 lb/gal) (245,328 LB @ \$0.14/lb)	\$ 34,346
Sulfuric Acid (27,974 lb @ \$0.04/lb)	\$ 1,119
Betz 1195 Cationic Polymer (57,360 lb @ \$1.45/lb)	\$ 83,172
Betz 1120 Anionic Polymer (1180 lb @ \$3.59/lb)	\$ 4,236
Sludge Disposal Cost (0.4 lb/gal) (182.5 tons @ \$220/ton)	\$ 40,150
Total Treatment Costs	\$193,535
Savings (without softening (without water reuse))	\$370,325
Savings (with softening (with water reuse))	\$655,157

[a] Based on Tinker AFB data for January 1 through June 30, 1988 and projected to 1 year. (141,913,000 gallons wastewater with 4454 lb of Cr+6 were treated in the 6 months)

sludge production weight for the process has not been determined. The metal sludge from the SCC is combined in the thickener with the wasted biological sludge from the activated sludge process. The high-pH sludge from the sulfuric acid/sulfur dioxide/lime process aided in filtering the biological sludge. In addition, the sludge was 50 percent lime metal sludge and 50 percent biological sludge.

Presently, the sludge is only 1/10 the volume of the original metal sludge volume. The two sludges are mixed; however, neither sludge settles well when mixed. The upper portion (overflow) from the sludge thickener is pumped to Mixer Basin 2 of the metal treatment process, therefore generating more sludge in the SCC. Normally, the thickened sludge from the thickener is filtered. The sludge, however, plugs the existing filter medium. To date, the filter manufacturer has not examined the filter or belt to determine the problem. Presently, the sludge is being disposed of at 1 to 2 percent solids by volume.

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APPENDIX A

INDUSTRIAL WASTEWATER TREATMENT PLANT

OPERATION AND MAINTENANCE MANUAL

IDAHO NATIONAL ENGINEERING LABORATORY

P. M. Wikoff
D. S. Prescott
D. F. Suciu

WALKER PROCESS CORPORATION

W. R. Carn
D. N. Ruehrwein

December 1988

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ABBREVIATIONS AND ACRONYMS

AFB	Air Force Base
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DFA	Continuous Flow Analyzer
DO	Dissolved Oxygen
E Tank	Equalization Tank
EPA	Environmental Protection Agency
F	Food
F/M	Food to Mass Ratio
FIC	Flow Indicator Controller
gph	Gallons per hour
gpm	Gallons per minute
HP	Horsepower
IWTP	Industrial Wastewater Treatment Plant
LIC	Level Indicator Controller
M	Mass
MCRT	Mean Cell Residence Time
mg/L	Milligrams per liter
MGD	Million Gallons Per Day
mL	Milliliter
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Units
P&I	Piping and Instrumentation
RAS	Return Activated Sludge
SCC	Solids Contract Clarifier
SCFM	Standard Cubic Feet Per Minute
SS	Suspended Solids
SVI	Sludge Volume Index
TDH	Total Dynamic Head
WAS	Waste Activated Sludge

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SECTION I

SAFETY PRECAUTIONS

Operation and maintenance of the Industrial Wastewater Treatment Plant (IWTP) requires operators to handle or be exposed to potentially hazardous chemicals. Personnel should be familiar with these chemicals and how to prevent injury to themselves and others. This section explains the chemical used in wastewater treatment and describes any special protective measures that should be used. In addition to the precautions described below, personnel should wear safety glasses when in the IWTP.

A. SODIUM SULFIDE

Sodium sulfide is a corrosive solid that can burn the skin. It reacts with acids to form hydrogen sulfide (H_2S), which is a colorless, very toxic gas that can be easily detected at concentrations greater than 10 ppm because it smells like rotten eggs. H_2S gas can react with the water in mucous membranes--such as the lining of the nose, eyes, and lungs--to form sulfuric acid that can cause serious burns. The gas is heavier than air, and settles in low places such as pits and basements.

Contact of the dry chemical with skin, especially if wet, should be avoided, but if contact should occur, flood the affected area immediately with water. If the rotten-egg odor of H_2S gas is detected, the area should be cleared immediately. If reentry is necessary before the gas has dissipated, personnel should be equipped with Class A protective suits and a self-contained breathing apparatus.

B. SULFURIC ACID

Sulfuric acid (H_2SO_4) is a very corrosive liquid that, in concentrated solution, reacts violently with water and will dehydrate and char the skin. Contact with the liquid or its vapor should be avoided. In case of accidental exposure, flood the affected area immediately with running water and follow established procedures for obtaining medical care as quickly as possible.

During maintenance or repair of the sulfuric acid pumps, piping, or tanks, personnel should wear acid-protective clothing (butyl rubber or polyethylene suit, gloves, and boots) and a full-face shield.

C. SODIUM HYDROXIDE

Sodium hydroxide (NaOH) is caustic in solid form and even more so in water solution. Contact with the skin can quickly cause severe burns. As with other chemicals, accidentally exposed skin should be immediately flooded with running water, and prompt medical treatment should be obtained.

During maintenance or repair of the NaOH pumps, piping, or tanks, personnel should wear base-protective clothing (butyl rubber or polyethylene suit, gloves, and boots) and a full-face shield.

D. CHLORINE GAS

Chlorine gas is very toxic and has a greenish-yellow color and a strong, biting odor. If it contacts the membranes of the lungs, eyes, nose, or mouth, it forms a corrosive liquid with the water in body fluids and causes severe tissue damage. In high concentrations, the gas can irritate dry skin.

At the slightest hint of a leak in the chlorine system, whether by sight, smell, or by detectors, the area should be cleared immediately. If reentry is necessary before the gas has dissipated, personnel should wear Class A chemical suits and a self-contained breathing apparatus.

SECTION II

OVERVIEW OF EQUIPMENT AND PROCESS/OPERATION

This section presents overviews of the plant's equipment and processes, and should be read before proceeding to the more detailed information in Section III.

The primary purpose of the IWTP is to treat industrial wastewater from the Tinker AFB processes for toxic metal, suspended solids, and to remove organic material before discharge into Soldier Creek. Before release into the creek, the effluent must meet the discharge limits established by the Environmental Protection Agency (EPA) or the National Pollution Discharge Elimination System (NPDES) permit requirements (Table 1).

TABLE 1. TINKER AFB NPDES PERMIT REQUIREMENTS

Constituent	Concentration Daily Maximum (mg/L)
Cadmium, Total	0.03
Chromium, Total	1.0
Chromium, Hexavalent	0.1
Copper, Total	0.1
Lead, Total	0.1
Nickel, Total	1.0
Zinc, Total	1.0
Phenols	0.05
Oil and Grease	15
Cyanide, Total	0.025
Chemical Oxygen Demand	150
Total Suspended Solids	30

The IWTP layout and the flow/instrumentation diagram are shown in Figures 1 and 2.

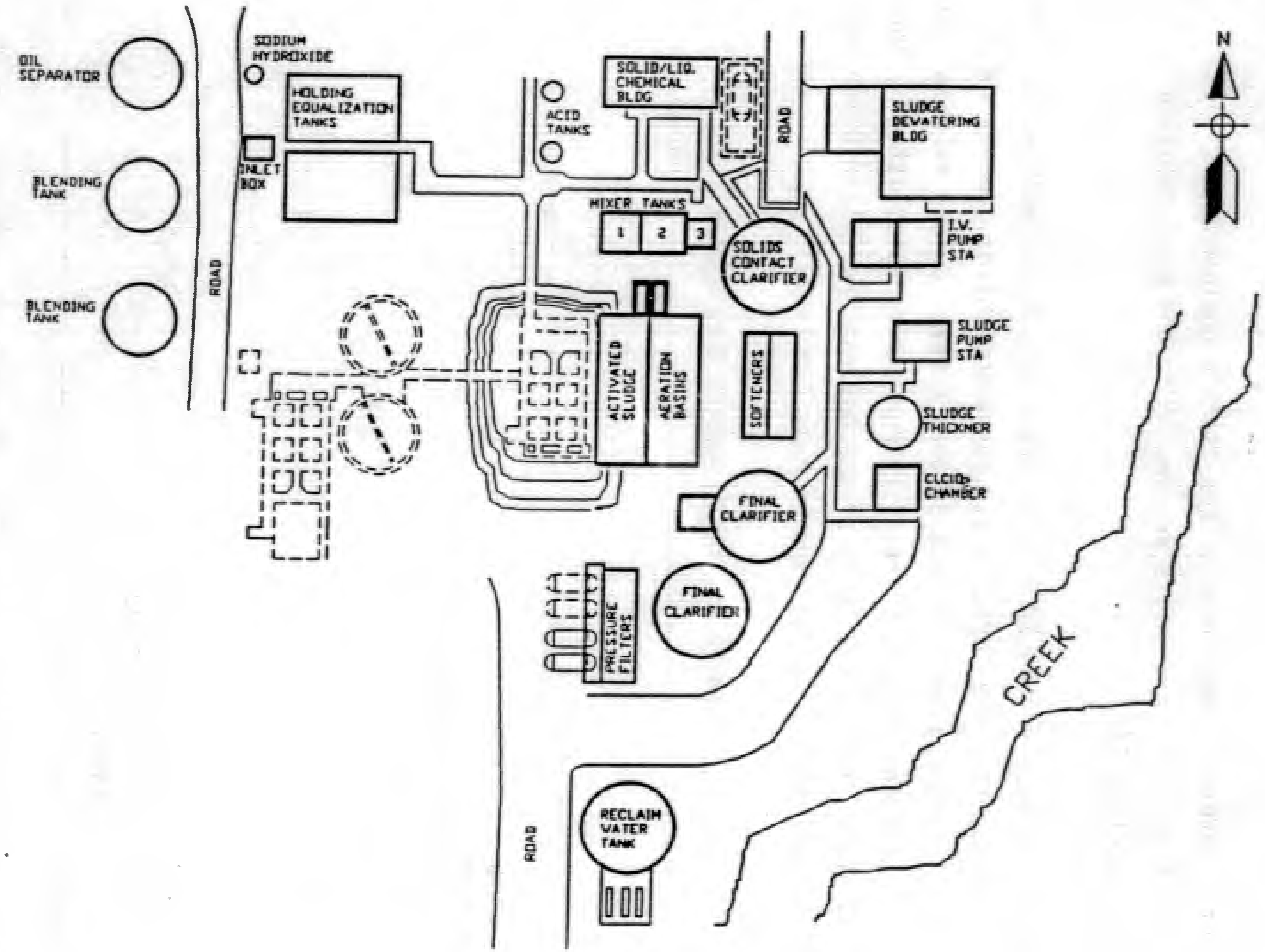
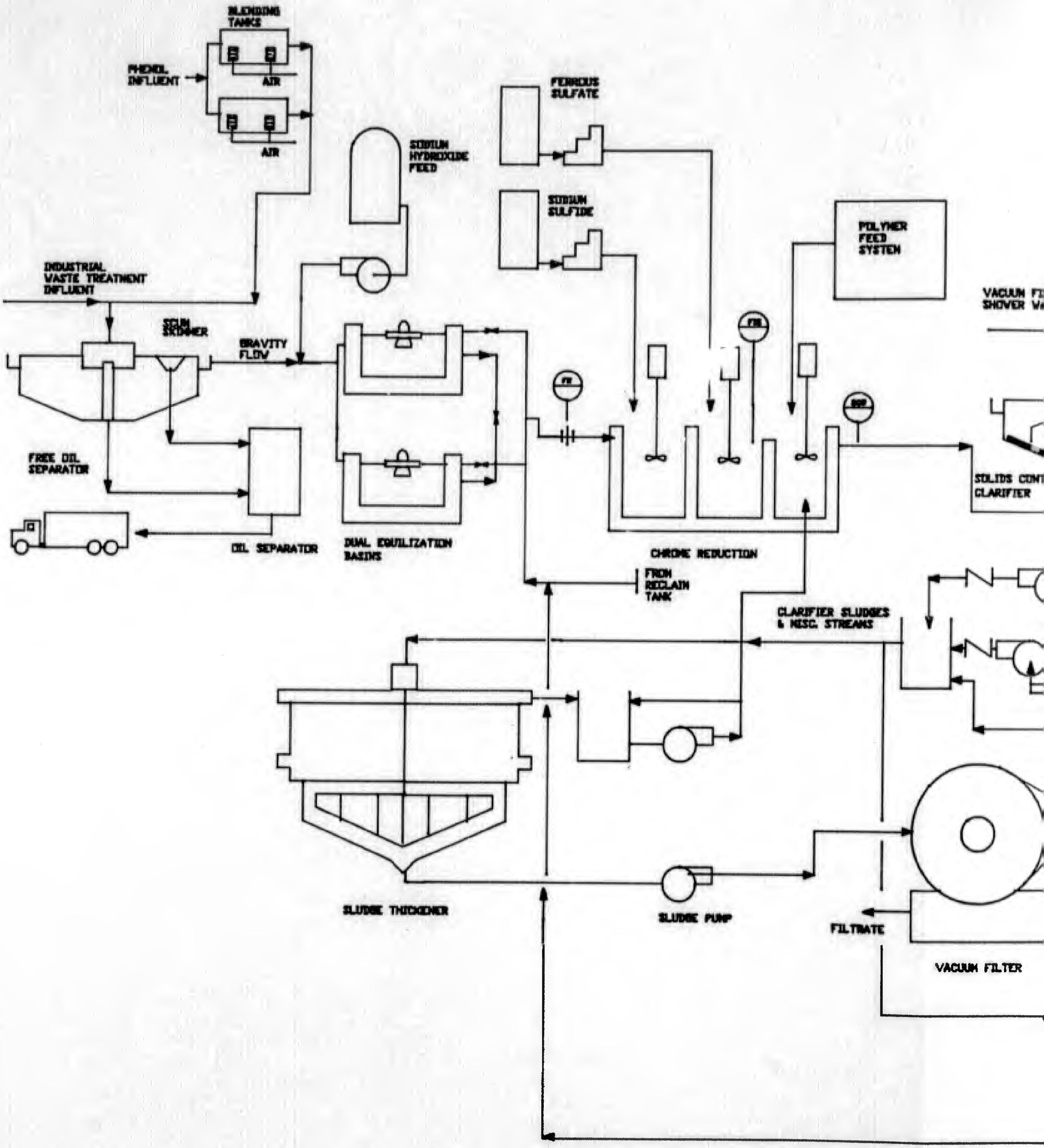


Figure 1. IWTP General Layout.


BLENDING TANKS
PHENOL INFLUENT
AIR
AIR
SODIUM HYDROXIDE FEED
FERROUS SULFATE
SODIUM SULFIDE
POLYMER FEED SYSTEM
VACUUM FI
SHOVER W
INDUSTRIAL WASTE TREATMENT INFLUENT
SCUM SKIMMER
GRAVITY FLOW
FREE OIL SEPARATOR
OIL SEPARATOR
DUAL EQUILIZATION BASINS
CHROME REDUCTION
SOLIDS CONT
CLARIFIER
FROM RECLAIM TANK
CLARIFIER SLUDGES & MISC. STREAMS
SLUDGE THICKENER
SLUDGE PUMP
FILTRATE
VACUUM FILTER

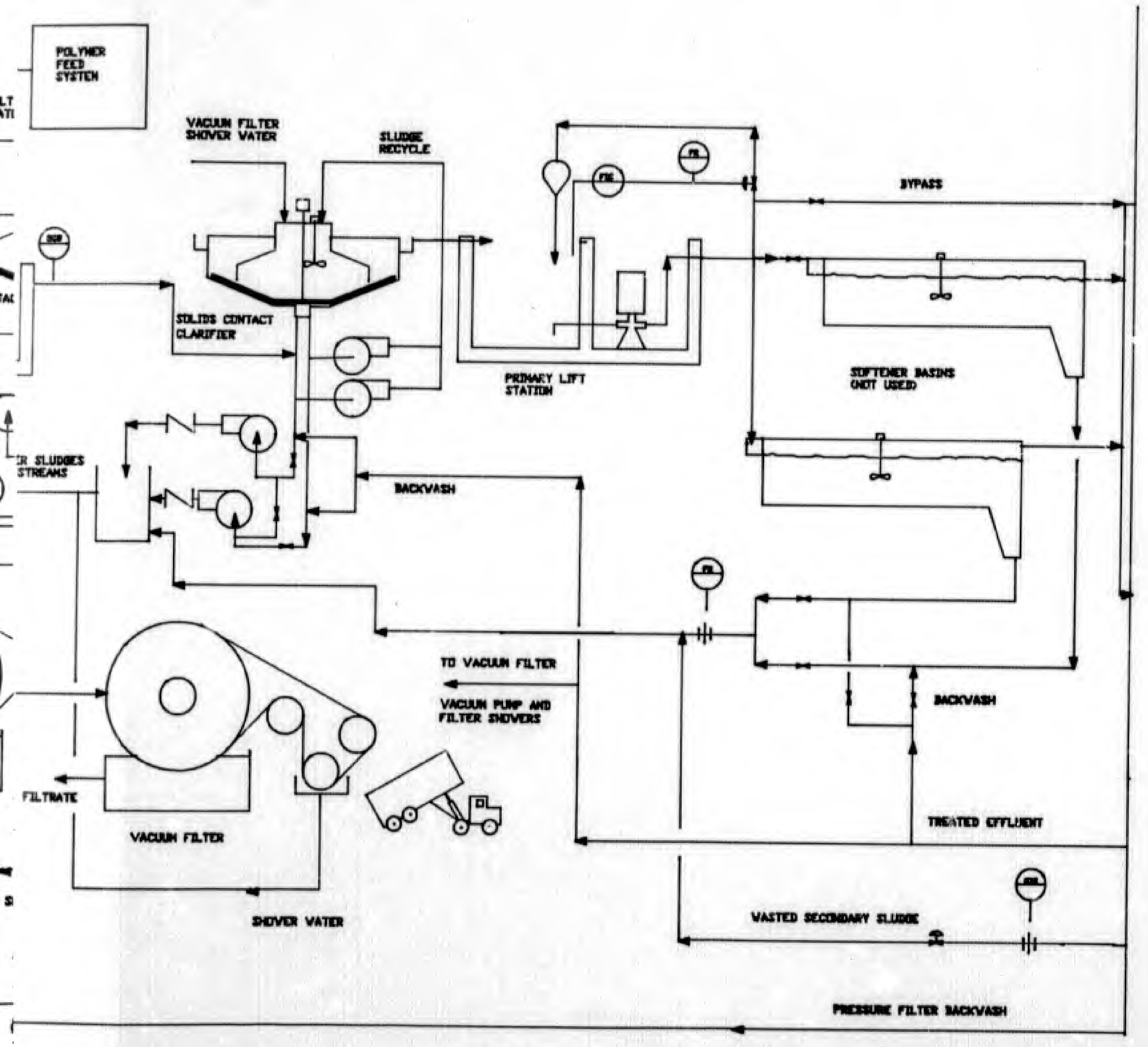


Figure 2. IWTP Flow/Instrumentation Diagram.

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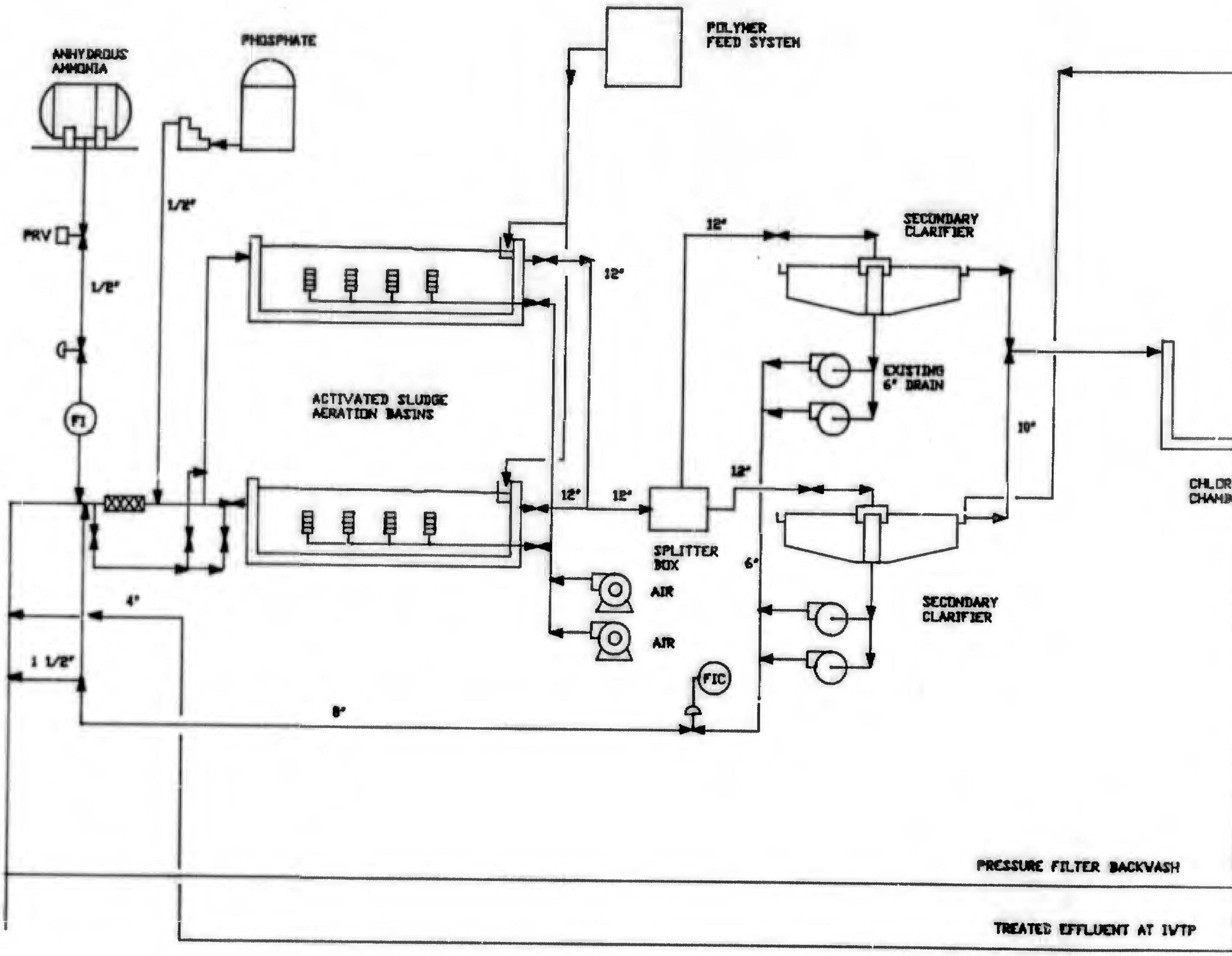
ANHYDROUS AMMONIA
PHOSPHATE
POLYMER FEED SYSTEM
PRV
1/2"
1/2"
FI
12"
SECONDARY CLARIFIER
12"
EXISTING 6" DRAIN
ACTIVATED SLUDGE AERATION BASINS
10"
12"
12"
12"
CHLORI
CHAMBE
SPLITTER BOX
6"
AIR
AIR
4"
SECONDARY CLARIFIER
1 1/2"
FIC
8"
PRESSURE FILTER BACKWASH
TREATED EFFLUENT AT IWTP

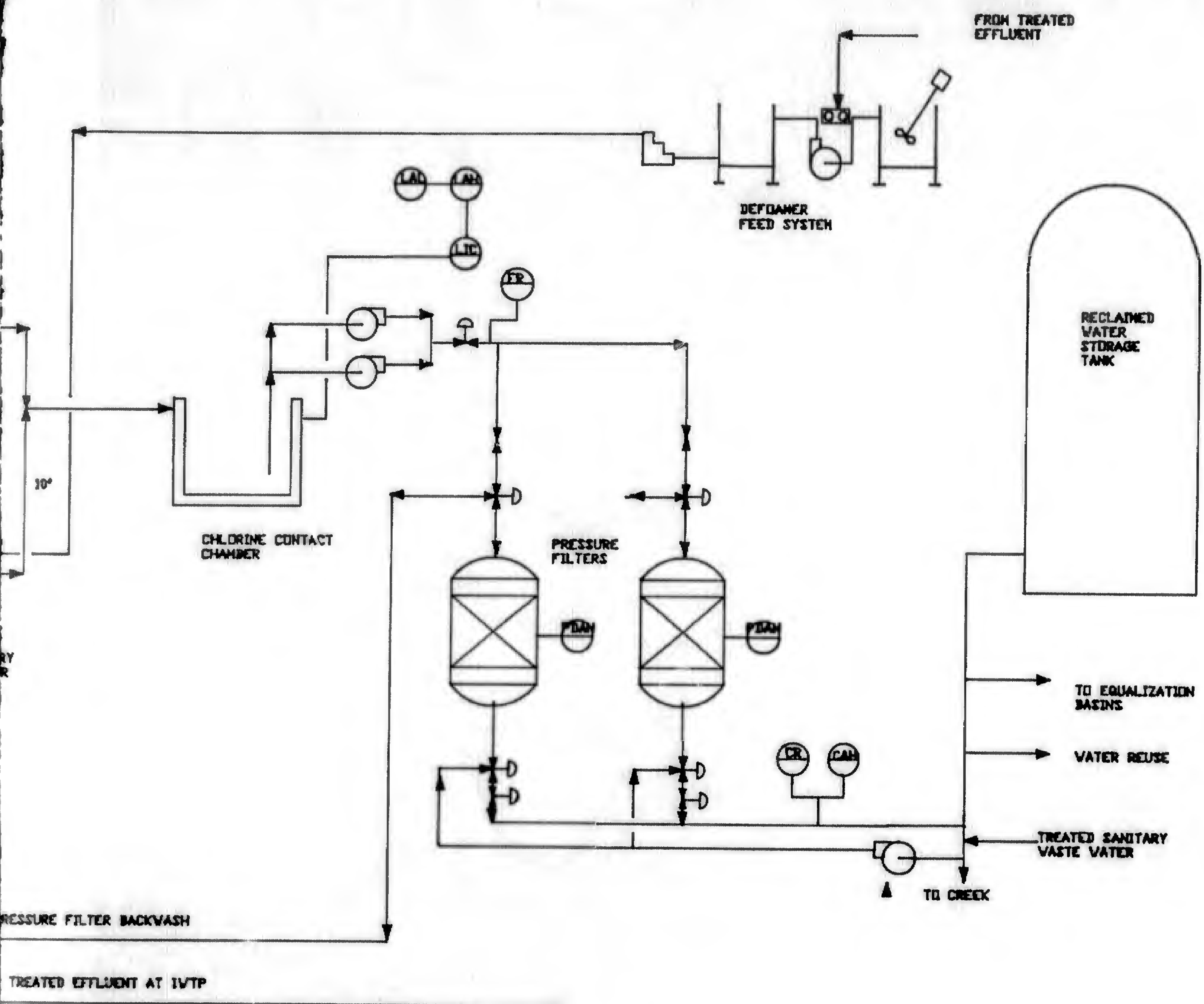

Figure 2. (continued)

A. EQUIPMENT OVERVIEW

The equipment overview description generally follows the flow of wastewater through the plant. A brief description of the major equipment and purpose of each follows.

- o Two blending tanks for equalizing of high phenol concentration flows. These tanks can be filled in parallel, but operate in series.
- o One oil separation tank.
- o Two parallel equalization tanks.
- o Three mixer basins in series for reducing chrome and precipitating metals.
- o One solids contact clarifier for flocculation and sedimentation of the precipitated metals.
- o One surge tank.
- o Two parallel activated sludge aeration basins for biological oxidation of organic compounds.
- o Two parallel activated sludge clarifiers for sedimentation of activated sludge mixed liquor.
- o One chlorine contact chamber for disinfecting and chemically oxidizing organic compounds.
- o Two parallel pressure filters for removing suspended solids.
- o One reclaimed water storage tank to hold treated water for possible reuse on the base.

- One sludge thickener tank for concentrating the waste sludge from the solids contact clarifier, surge tanks, and activated sludge clarifiers.

- One vacuum belt filter for dewatering the concentrated sludge from the sludge thickener.

B. PROCESS AND OPERATIONAL OVERVIEW

Tinker Air Force Base produces wastewater laden with metals and phenol as a byproduct of their aircraft maintenance procedures. Free oil and oil-wet solids are also present in the wastewater.

The treatment processes described in this manual chemically reduce and precipitate the metals and biologically oxidize the phenols, producing reusable process water (an effluent which meets regulatory discharge limitations) and a reduced volume of sludge. Production of the high-quality effluent on a continuous basis requires constant monitoring and adjustment at the various treatment stages.

The chemical and biological sludges that are byproducts of the process are treated and dewatered before disposal. The oils and oily solids are separated and stored for disposal.

The process includes pH adjustment, the addition of sodium sulfide and ferrous sulfate to reduce metals, and an activated sludge process to oxidize phenols.

All of the treatment processes in the IWTP are sensitive to changes in quantity and quality of the incoming wastewater. The operator must anticipate such changes and make proper adjustments to the plant operation. The operator must also anticipate the need to change the feed rate of treatment chemicals. For example, an increase in chrome concentration or flow will require increasing the feed rate of sodium sulfide and ferrous sulfate to Mixer Basins 1 and 2. This change may require increasing the feed rate of anionic polymer to obtain adequate flocculation and clarification in the solids contact clarifier.

In addition, there is normally a dramatic reduction in plant influent flow during weekends and long holiday periods. This prolonged reduction in flow can have an adverse effect on biological treatment. Before these periods, the operator should increase the liquid level in the equalization tank. The wastewater in the holding tank can then be used to maintain a reduced flow throughout this low-flow period.

In summary, the operator should realize that the various treatment processes are all interrelated. Producing high-quality effluent on a consistent basis requires that all processes be closely monitored and controlled.

Test programs and procedures noted in this manual are intended for process control and to assist in preventing process upsets. They are not intended to be responsive to regulatory requirements, which are beyond the scope of this manual.

The descriptions refer to Figure 1 (general equipment layout) and Figure 2 (process flow/instrumentation diagram). Referring to these figures will aid in locating major equipment and understanding the process logic.

The remaining discussion in this overview covers, in general, the process and operational logic. Each piece of equipment and process step is covered in greater detail in Section III. Major equipment discussed in detail is underlined in the overview. The discussion follows the process step-by-step from the raw influent flow into the treatment plant to the treated effluent flow into a reuse water tank or surface water.

1. Blending, Oil Removal, and Equalization

Wastewater enters the system in two streams. The principal flow enters a gravity <u>oil separator</u> for removal of floatable and settleable oily wastes. A secondary flow, high in phenols, enters one of two blending tanks. The phenols from the blending tanks are manually fed into the oil separator on a timed basis to provide a reasonably uniform phenol loading to the treatment process.

The clarified influent flows by gravity to one of two equalization tanks. The pH of the stream is monitored upstream of the basins and is adjusted to 7.0 or greater in the oil separator outlet. The equalization basins smooth influent flow, reduce containment concentration variations, and provide complete mixing. The flow rate to the treatment plant is controlled at the discharge of the basins. The basins are operated on a batch mode when possible to assure stable hexavalent chromium (Cr^{+6}) concentration of the contents, which is an extremely important process requirement.

2. Metals Reduction

The flow enters the first of three mixer basins. Sodium sulfide is added to the first basin, ferrous sulfate and sulfuric acid to the second, and a cationic polymer to the third. The three mixing basins provide the chemical and physical environment needed to reduce chrome and other metals to a settleable precipitate. The polymer is added as a flocculation aid for the subsequent clarification process.

3. Primary Clarification

The Solids Contact Clarifier (SCC) provides a quiescent environment permitting flocculation and clarification of the flow. A high solids concentration requirement is maintained by an external sludge recycle system operating in parallel with equipment for moving excess sludge to the sludge thickener.

The clarified flow enters two parallel softener basins previously used for a carbonate hardness softening process. The new sulfide/sulfate process eliminates this softening requirement. The basins are used only for additional clarification of the clarified effluent.

The next process uses two parallel activated sludge basins. This aerobic biological process requires air injection for mixing and as an oxygen supply, nutrient addition, and recycling of the biologically active solids to maintain a high solids concentration in the basins. Excess solids are wasted and pumped to the sludge thickener.

The principal requirement of the activated sludge basins is the proper ratio of carbon, oxygen, nitrogen, and phosphorus for oxidation of the phenols in the effluent. Nitrogen is added as ammonia, phosphorus as phosphoric acid, and carbon as phenols and other organic compounds.

4. Secondary Clarification

The effluent from the activated sludge basins contains biological solids that must be removed before discharge or reuse of the water. The secondary clarifier separates these biologically active solids and returns them to the activated sludge basins or wastes the excess to the sludge thickener.

5. Polishing and Disinfecting

The chlorine contact chamber provides an extended hydraulic retention time for contact of the treated water and the added chlorine. The chlorine provides for additional phenol polishing and disinfecting of the treated water. Dosage rates are adjusted to provide a low level of residual chlorine in the discharged water.

6. Final Filtration

Pressure filters are used to remove any filterable solids before discharge of the treated water to the reuse tank or the environment.

7. Sludge Thickening, Filtration, and Disposal

The waste sludges from the solids contact clarifier and the secondary clarifiers are fed to a gravity sludge thickener. Liquid effluent is returned to the third mixing chamber; thickened sludge is pumped to a belt vacuum filter. The mixed, dewatered sludges are loaded in trucks for disposal.

SECTION III

EQUIPMENT DESCRIPTION AND OPERATING/MAINTENANCE INSTRUCTIONS

A. BLENDING TANKS

The purpose of the blending tanks is to segregate and temporarily store waste streams which contain high concentrations of phenols. The liquid in the blending tanks can then be fed into the oil separator at a controlled rate in an attempt to maintain a more constant phenol concentration in the biological treatment process.

1. Equipment

Each concrete blending tank is 60 feet in diameter, 12 feet high at the side walls, and has a flat bottom. Each tank holds 250,000 gallons, and has aeration piping located near its bottom. Portable air compressors can be brought to the blending tanks for use with the aeration piping when needed.

The two blending tanks are operated in series, but can be filled at the same time. The influent flow splits at a "y" fitting; a pipe leading to each blending tank. Valves on the influent pipe to each blending tank allow flow to be directed to either tank. The tanks are connected by an equalization line, which allows the level to balance between the two tanks. The equalization line is valved so that each tank can be isolated. The liquid in the north tank is pumped to the oil separator by a timer-controlled pump.

2. Normal Operation

a. Operating Strategy

Flow into the blending tanks depends on operations in the maintenance facility. The influent is directed into the south blending tank by opening the influent valve on the south tank and closing the influent valve on the north tank. The liquid in the south tank is allowed to flow into the north tank through the equalization line by opening the valve in the equalization line. The liquid in the north tank is fed into the oil separator or by pump through a transfer line.

The transfer pump is controlled by a manual-off automatic switch. The pump operates continuously in the manual mode and is controlled by an on-interval timer in the automatic mode. The on-interval timer has a maximum on time of 99 hours, with a minimum setting of 0.1 hour.

Influent should be pumped from the blending tanks as a result of either of two conditions:

- o Pumping is based on loading for that day, and not on a set minimum or maximum concentration, or
- o When discharge to the blending tanks exceeds the currently available storage volume in the tanks.

A gradual transfer of liquid from the blending tanks must begin as soon as one of the above conditions is suspected. At that time, the required transfer volume should be determined by subtracting the currently available volume from expected discharge volume. The required transfer volume should be divided by the time in days before the transfer must be completed. This daily transfer volume should spread out throughout the day as evenly as possible. If the phenol concentration is greater than that permitted in the equalization tank, the phenol must be treated at the blending tanks and the equalization tanks, which is accomplished by adding potassium permanganate and by aeration. With the present system design, there are times when the blending tanks cannot accept all the flow even if the tanks are empty before the planned discharge. The excess flow must then go through the industrial treatment plant, and therefore must be treated to degrade the phenol to a level which will not be harmful to the activated sludge process and which the activated sludge process can degrade to NPDES permit requirement limits.

b. Sampling and Analysis

NOTE

Twenty-four-hour composite samples should be collected from the north blending tank on days when transfer to the oil separator is contemplated or when influent with a high concentration of phenol is expected.

These samples are analyzed for phenol concentration in accordance with Procedure 510B of Standard Methods for the Examination of Water and Wastewater.

Other sampling and analysis, as required by regulating agencies or in-house projects, should also be performed.

3. Maintenance

The sludge depth is determined weekly by use of a probe or a core sample tube. Once a year, or more often if required, the tanks should be pumped out and cleaned. All sludge should be removed. The aeration piping should be inspected at this time and cleaned, repaired, or replaced as necessary.

The portable air compressor, transfer pump, and associated valves should be maintained as recommended in the manufacturer's instructions.

4. Primary Duties of the Shift Operator

- o Consult with the previous shift operator to determine (a) the results of previous tests and sample analyses and (b) operating strategies currently in use.

- o Contact the aircraft maintenance scheduling personnel to determine the planned discharge of phenol-containing wastes.

- Determine the liquid level in the blending tanks.

- Evaluate the need to revise the current operating strategy based on the current liquid levels and the phenol waste discharge plans.

- Monitor or revise the blending tank transfer rate to be consistent with the operating strategy.

5. Startup Procedure

Startup of the blending tanks requires setting influent and equalization valves according to the operating strategy and priming the transfer pump suction line.

6. Shutdown Procedure

Temporary shutdown of the blending tanks requires no action. Long-term shutdown requires pumping out the tanks, removing any accumulated sludge, and washing down the tanks. The portable air compressor and transfer pump should be placed in long-term storage in accordance with the manufacturer's instructions.

7. Abnormal Occurrences

Excessive amounts of paint chips or other solids being discharged into the blending tanks will result in rapid sludge buildup. This problem should be identified in the weekly sludge level determination and stopped at its source if possible. Depending on the severity of the problem, sludge removal may be required. The aeration headers may be turned on to stir up the sludge when the sludge depth becomes excessive and tank cleanout is not practical. Aeration will keep much of the solids in suspension and result in transfer of those solids from one blending tank to the other and from the blending tanks to the oil separator.

Uneven liquid levels in the two tanks may be the result of a clogged equalization line or a malfunctioning valve in the equalization line. Depending on the extent of the clogging, it may be necessary to pump out both tanks so that the valve or line are accessible for repair or cleaning.

Inability to transfer liquid from the blending tank to the oil separator may be caused by a malfunctioning pump, a clogged pipe, a loss of prime on the pump suction, or an air lock in the pump discharge line. In these cases, repairing the pump, cleaning out the pipe, priming the suction line, or releasing trapped air from the discharge line should solve the problem.

If expected discharges to the blending tanks require a transfer rate that results in a phenol concentration that is too high for adequate removal in biological treatment process (and would result in a violation of the effluent limitations of the plant), one of these procedures must be followed:

- o Provide additional storage volume in the blending tank by pumping liquid out of the tanks into tank trucks for temporary off-line storage or disposal.

- o Have the planned discharge delayed until a later time when the treatment plant conditions will allow satisfactory storage and treatment of that discharge.

- o Treat the phenol with aeration and by adding potassium permanganate.

B. OIL SEPARATOR

The oil separator receives all wastewater flows from the facility and provides primary removal of oils and greases. The separator's surface skimmer and bottom rake mechanism facilitates removal of floatable and settleable materials.

Two flow streams enter the influent well of the oil separator. The principal stream is the general industrial waste coming from aircraft maintenance operations. The secondary waste stream, consisting of high strength phenol wastes from paint stripping operations, is blended with the principal stream. In addition, in the case of low pH (pH <7) caustic is pumped into the effluent well.

The oil separator provides a quiescent environment, permitting floatable materials to move to the liquid surface and settleable materials to drop to the tank floor. Floatables are skimmed by the slowly rotating mechanism and collected in a peripheral box.

The dual-bottom rake arms use a series of squeegees to move settled materials to an eccentric bottom hopper. The skimmed and settled materials are deposited in an oil-collection sump and are transferred via a belt skimmer to transportable waste oil containers.

1. Equipment

The separator is a concrete tank with a 60-foot diameter, a 9-foot side depth, and a 1- to 12-inch bottom floor slope. The principal flow enters at the bottom center, flows upward through the center support pier, and discharges inside the influent well. The secondary flow stream from the blending tanks discharges directly into the influent well.

The skimmer mechanism is supported by the center pier and includes the bottom truss and plow structure and the top skimmer. The mechanism is rotated by an electric motor driving through a multiple reduction gear mounted on top of the center pier. A bridge providing personnel access and electrical service connects the tank wall and the center pier. Caustic is pumped from caustic storage shed into the influent well to adjust the pH of the wastewater to higher than 7. The caustic feed is controlled by a pH probe in the effluent line just upstream of the equalization tank. The pH alarm is located in the control room.

2. Normal Operation

a. Operating Strategy

The oil separator receives the wastewater flows from the various sources. There is no operating strategy for this equipment.

b. Sampling and Testing

The separator will, at design hydraulic loadings, consistently produce an effluent with free oil concentrations less than 25 mg/liter as measured by partition-gravimetric methods. Routine sampling and testing of the effluent is not required to protect the downstream wastewater treatment process. Samples and tests, if any, required by regulatory bodies are beyond the scope of this manual.

Testing is recommended under upset conditions as noted in the Abnormal Occurrences section.

3. Maintenance

Oil separator maintenance is limited to routine electrical and mechanical maintenance as specified by the equipment manufacturer. The caustic feed pump should be maintained according to the routine maintenance described in the manufacturer's manual. Coatings on the concrete tank and structural steel members should be renewed as required to protect their integrity or appearance.

It is recommended that every three years the oil separator tank be drained, cleaned, and inspected. Concrete and structural steel members should be inspected for deterioration and repaired as required. The rake arm squeegees should be replaced if worn; the mechanism should be inspected for level and any evidence of contact with the tank. The influent and effluent lines should be flushed. The skimmer mechanism, including wiper materials and articulating members, should be carefully inspected for wear and replaced as required.

The pH probe should be cleaned daily with soapy water followed by a dilute sulfuric acid solution (<10%), then calibrated according to the manufacturer's instructions.

4. Primary Duties of the Shift Operator

- o Consult with the previous shift operator to determine (a) Results of previous tests and samples, and (b) operating status of all electrical and mechanical equipment.
- o Check for proper operation of the separator mechanism.
- o Check the drive torque.
- o Look for excessive oil buildup on the surface of the separator or oil being carried out with the separator effluent.
- o Clean and calibrate the pH probe daily.
- o Check the level of the caustic in the feed tank and switch tanks when appropriate.
- o Check the number of full caustic tanks and reorder when appropriate.

5. Startup Procedure

The manufacturer's installation and operation manual should be reviewed before starting or restarting the mechanism.

Startup procedures should include checks on lubrication levels and changes in the electrical current draw, direction of rotation, skimmer to beach clearances, etc.

After monitoring the rotation of the mechanism for several full revolutions, wastewater can be introduced.

6. Shutdown Procedure

The oil separator mechanism can be shut down for routine preventive maintenance such as oil changes, inspections, etc., without shutting off the influent flow. The influent flow must be shut off if floatables collect to the height of the scum baffle or the settleable materials are of sufficient density and quantity to cause rake arm torque overload alarms.

Shutdowns involving tank draining and cleaning should include continued rotation of the mechanism to aid bottom cleanout.

7. Abnormal Occurrences

Abnormal mechanical or structural problems may occur as a result of equipment or electrical breakdown. The equipment manufacturer or his instructions should be consulted for repair procedures.

Torque alarms or shutdowns are indications of separator mechanism contact with the tank or abnormal buildup of settleable materials.

Excess oil carryover can result from:

- Influent temperature rate of change in excess of 5°F/hour.
- Influent flow rate greater than design.
- Free influent oil quantity great enough to permit an oil buildup in excess of the skimmer and scum baffle capacity.
- Equipment breakdown.

C. EQUALIZATION TANKS

The purpose of the equalization tanks is to allow pH adjustment and consistent quality batch flow to the chromium reduction and activated sludge process. The tanks receive the flow from the oil separator and prevent flow or concentration surges through the plant.

1. Equipment

The equalization tanks are two 500,000-gallon concrete tanks. Four surface aeration pumps mix each of the tanks. The principal plant flow meter indicates the flow in the combined effluent line from these tanks.

2. Normal Operation

a. Operating Strategy

Each tank is filled separately with the effluent from the oil separator by opening the inlet valve. During filling, the pH is checked and, if required, the pH is adjusted with caustic. When the first tank is full, its inlet valve is closed and its outlet valve is opened. To fill the second tank, its inlet valve is opened and its outlet valve is closed.

b. Sampling and Analysis

Before treating the wastewater, the pH must be above 7.2 to prevent off-gassing of hydrogen sulfide gas from Mixer Basin 1 where the sodium sulfide is added. Hydrogen sulfide is a noxious gas and can be toxic. A pH probe, readout, and alarm is located at the inlet (west side) of the equalization tanks. The meter is set to alarm if the pH falls below 7.2. The pH should be monitored in the equalization tank to ensure that the pH remains above 7.2. Although chromium reduction is not affected by a high pH in the influent, pumping excess caustic increases the cost of chemicals, so the pH should be monitored carefully to ensure that excess caustic is not being pumped. Normally, the pH is greater than 7.2, so that caustic addition would not be a daily procedure. But when required, its addition is critical to plant operations and safety.

Before sending the wastewater to the remainder of the treatment plant, a sample of the wastewater in the equalization tank must be analyzed for hexavalent chromium. The analysis method is the Hach Chemical Company diphenyl carbazide colorometric method. The results of this analysis are used to set the chemical feed pumps at Mixer Basins 1 and 2. Flow rate is set at the outlet of the equalization tank. (The flow indicator and control are located in the control panel in the solid/liquid chemical feed building.) The flow rate is set so that the first equalization tank does not empty during the filling of the second tank. In other words, the filling rate should match the emptying rate. Level indicators are located at the same control panel as the flowmeter.

3. Maintenance

To keep the equalization tanks in proper condition, the surface aeration pumps, the flowmeter, and the level indicator should be maintained according to the routine maintenance described in the manufacturer's manual.

Every three years, the equalization tanks should be drained, any sludge removed from the bottom of the tanks, and the tank cleaned. The tanks should be inspected for cracks or other deterioration. Any repairs should be made while the tanks are empty and clean. Also, the inlet and outlet lines should be cleaned to prevent plugging, the pumps and flowmeter should be tested, and all replacement kits installed according to the manufacturer's instruction.

The flowmeter should be inspected every six months, or whenever the flow appears erratic, to ensure that no plugging and scaling has occurred in the flowmeter.

4. Primary Duties of the Shift Operator

- Consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- Check the operation of the aerators, chemical feed system, and the flow rate control valve.

- Check the pH in the equalization basins to ensure that the pH is correct and that caustic is feeding correctly.

o Monitor the level in the equalization tanks and determine when to switch equalization tanks.

5. Startup Procedure

If the equalization tank has been drained or if it has not been in use for some time, the outlet valves should be checked to ensure that they are closed and the inlet valve should be opened. If the pH is lower than 7.2, the caustic valve should be opened and the caustic feed pump turned on. When the level in the equalization tank is 3 feet, the aeration pump should be turned on.

6. Shutdown Procedure

In order to drain the tanks or discontinue operation, the wastewater inlet valves, caustic feed valves, and the caustic feed pump should be shut off. If the tank is to remain full, the aeration mixer pumps should be left on and the outlet valve should be closed. If the tank is to be drained, the aeration pumps should be turned off and the waste outlet valve opened to drain the tank. The sludge should be pumped out of the bottom of the equalization tank. All valves should be closed while the tank is down.

7. Abnormal Conditions

If the flow rate has been set and the flowmeter readout does not continue to correspond to the setting, there may be problems with the flow-regulating valve. The valve should be checked and repaired according to the manufacturer's instruction manual. Another cause may be a plugged outlet line. If plugging has occurred, the line should be cleaned and flushed.

The operation of the surface aeration pump is critical to obtaining a well mixed batch for discharge through treatment plant and for obtaining a representative sample for pH and hexavalent chromium analysis. If a pump is not working, it should be repaired immediately.

If the pH at the west end of the equalization tank reads less than 7.2, even though the pH alarm has not sounded, verify that the pH probe is working at the oil-separation effluent and check to see that the portable pH probe is reading correctly. If the pH is actually low, the caustic feed to the oil separator effluent well should be started and the pH brought above 7.2 before flow is started from the tank. If the alarm has sounded and the caustic feed has been started but the pH remains low, check to see that the caustic is actually feeding, the line is not plugged, the caustic pump is working correctly, and the caustic tank is not empty. If the caustic is feeding correctly and the pH probes are working, continue to feed the caustic until the pH is 7.2 before starting flow to the plant.

D. MIXER BASIN 1

The purpose of Mixer Basin 1 is to mix sodium sulfide with the industrial wastewater. Sodium sulfide is the source of sulfide for metal precipitation and is one of the chemicals needed to reduce hexavalent chromium.

1. Equipment

Mixer Basin 1 is a concrete tank (13 x 14 x 16 feet) which contains an axial flow impeller mixer. Included with the mixer basin is a 7000-gallon insulated, heated, bulk storage tank for the sodium sulfide solution, tank mixer, and two sodium sulfide feed pumps.

2. Normal Operation

a. Operating Strategy

The wastewater flows from the equalization tank, at a controlled flow rate and predetermined hexavalent chromium concentration, into the bottom of the east side of Mixer Basin 1. The sulfide solution is fed into the south wall approximately at the center, its flow rate is set as a function of the hexavalent chromium concentration and flow rate. The wastewater/sulfide mixture gravity flows over the west wall of Mixer Basin 1.

The sulfide concentration is 2 mg/liter per 1 mg/liter hexavalent chromium. It is critical to the chromium reduction metal removal process that the sulfide feed ratio remains at this value. If too much sulfide is fed, the metal precipitate will not be removed at the solids contact clarifier since a very fine black precipitate forms. If not enough sulfide is fed, the hexavalent chromium will not be reduced completely and insufficient sulfide will be available for precipitating the other heavy metals. The sulfide feed requirement as a function of hexavalent chromium concentration and influent flow rate is given in Tables 2 and 3. The sulfide feed rate can be set at the sulfide feed pumps or the instrument panel.

b. Sampling and Testing

The primary sampling requirement for operation of Mixer Basin 1, is the sampling of the sulfide in the feed tank to ensure that the feed has not deteriorated with time. This should be sampled weekly using the Orion Specific Ion Meter and the specific ion probe for sulfide. Also,the equalization tank contents should be analyzed every two hours for hexavalent chromium and pH to maintain the wastewater influent above pH 7.2. The sulfide feed pumps should be calibrated weekly to ensure the correct sulfide feed.

3. Maintenance

Maintenance of Mixer Basin 1 consists of maintaining the mixer in the chamber, the sulfide chemical feed pumps, the chemical feed tank mixer, and the tank heater. Routine maintenance should be performed according to the manufacturer's manuals provided with the equipment. In addition, the mixer basin should be pumped out and cleaned once every three years. The basin walls and the bottom should be checked for any cracks or leaks and these repaired. At the same time, the basin mixer should be checked out according to the manufacturer's instruction and any repair kits installed.

TABLE 2. REQUIRED SODIUM SULFIDE FEED RATE AS A FUNCTION OF IWTP INFLUENT FLOW RATE AND HEXAVALENT CHROMIUM CONCENTRATION (124,000 mg/L S_2).

Cr+6 (mg/L)	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Influent Flow (mgd)	Required Sulfide Feed Rate (mL/min)																				
0.10	5	6	6	7	8	9	10	11	12	13	14	15	16	17	18	18	19	20	21	22	23
0.15	7	8	10	11	12	14	15	17	18	19	21	22	23	25	26	28	29	30	32	33	35
0.20	9	11	13	15	17	18	20	22	24	26	28	29	31	33	35	37	39	41	42	44	46
0.25	12	14	16	18	21	23	25	28	30	32	35	37	39	41	44	46	48	51	53	55	58
0.30	14	17	19	22	25	28	30	33	36	39	41	44	47	50	53	55	58	61	64	66	69
0.35	16	19	23	26	29	32	35	39	42	45	48	52	55	58	61	64	68	71	74	77	81
0.40	18	22	26	29	33	37	41	44	48	52	55	59	63	66	70	74	77	81	85	88	92
0.45	21	25	29	33	37	41	46	50	54	58	62	66	70	75	79	83	87	91	95	99	104
0.50	23	28	32	37	41	46	51	55	60	64	69	74	78	83	88	92	97	101	106	111	115
0.55	25	30	35	41	46	51	56	61	66	71	76	81	86	91	96	101	106	111	117	122	127
0.60	28	33	39	44	50	55	61	66	72	77	83	88	94	99	105	111	116	122	127	133	138
0.65	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	126	132	138	144	150
0.70	32	39	45	52	58	64	71	77	84	90	97	103	110	116	123	129	135	142	148	155	161
0.75	35	41	48	55	62	69	76	83	90	97	104	111	117	124	131	138	145	152	159	166	173
0.80	37	44	52	59	66	74	81	88	96	103	111	118	125	133	140	147	155	162	169	177	184
0.85	39	47	55	63	70	78	86	94	102	110	117	125	133	141	149	157	164	172	180	188	196
0.90	41	50	58	66	75	83	91	99	108	116	124	133	141	149	158	166	174	182	191	199	207
0.95	44	53	61	70	79	88	96	105	114	123	131	140	149	158	166	175	184	193	201	210	219
1.00	46	55	64	74	83	92	101	111	120	129	138	147	157	166	175	184	193	203	212	221	230
1.05	48	58	68	77	87	97	106	116	126	135	145	155	164	174	184	193	203	213	222	232	242
1.10	51	61	71	81	91	101	111	122	132	142	152	162	172	182	193	203	213	223	233	243	253
1.15	53	64	74	85	95	106	117	127	138	148	159	169	180	191	201	212	222	233	244	254	265
1.20	55	66	77	88	99	111	122	133	144	155	166	177	188	199	210	221	232	243	254	265	276
1.25	58	69	81	92	104	115	127	138	150	161	173	184	196	207	219	230	242	253	265	276	288
1.30	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	239	251	263	275	287	299
1.35	62	75	87	99	112	124	137	149	162	174	187	199	211	224	236	249	261	274	286	298	311
1.40	64	77	90	103	116	129	142	155	168	181	193	206	219	232	245	258	271	284	297	309	322
1.45	67	80	93	107	120	134	147	160	174	187	200	214	227	240	254	267	280	294	307	321	334
1.50	69	83	97	111	124	138	152	166	180	193	207	221	235	249	263	276	290	304	318	332	345

TABLE 3. EXAMPLES OF SODIUM SULFIDE PUMP SETTINGS AS A FUNCTION OF SULFIDE FEED REQUIREMENTS.

Sulfide (mL/min)	30 % Stroke (SPM)	50% Stroke (SPM)	70% Stroke SPM
10	1	1	1
20	3	2	1
30	4	3	2
40	5	3	3
50	7	4	3
60	8	5	4
70	9	6	5
80	11	7	5
90	12	8	6
100	13	8	6
110	15	9	7
120	16	10	8
130	17	11	9
140	19	12	10
150	20	23	10
160	21	14	11
170	23	15	12
180	24	15	12
190	25	15	13
200	27	17	14
210	28	18	14
220	29	19	15
230	30	20	16
240	32	21	16
250	33	21	17
260	34	22	18
270	36	23	18
280	37	24	19
290	38	25	20
300	40	26	20
310	41	27	21
320	42	27	22
330	44	28	22
340	45	29	23
350	46	30	24
360	48	31	25
370	49	32	25
380	50	33	26
400	53	34	27
410	54	35	28
420	56	36	29
430	57	37	29
450	60	39	31
460	61	39	31
470	62	40	32
480	64	41	33
490	65	42	33
500	66	43	34

The mixer impeller and shaft should be examined at this time for any cracks or signs of excess wear and, if necessary, repaired.

During cold weather, the chemical storage tank and heat taped chemical feed line should be checked daily to make sure the heaters are working properly.

4. Primary Duties of the Shift Operator

- Consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- During freezing weather, check the operation of the sodium sulfide storage tank and piping heaters.

- Check the operation of the mixer and the sodium sulfide feed system.

- Review plant flow rate, hexavalent chromium concentration, and planned sodium sulfide dosage rate.

- Verify that the correct sodium sulfide dosage rate is being used.

- Check the level in the sodium sulfide storage tank and reorder when appropriate.

5. Startup Procedure

To start up Mixer Basin 1, open the sodium sulfide feed line valve and the inlet wastewater valve. Start the sodium sulfide feed and turn on the basin mixer.

6. Shutdown Procedure

To shut down the mixer basin, close the wastewater inlet valve, shut off the chemical feed pump, and then shut the chemical feed valves. Pump the wastewater from the mixer basin to either Mixer Basin 2 or to a tank truck. If the sodium sulfide feed tank is to remain full, the tank mixer and heaters should remain on. Otherwise, the sulfide should be pumped out of the tank, the heaters and mixers shut off, the tank flushed out, and the chemical feed lines drained.

7. Abnormal Occurrences

If the sulfide is not being fed, start the standby chemical feed pump and set at the required feed rate. Check to make sure it is feeding sulfide. If it is, check out the failed chemical feed pump according to manufacturer's instructions and repair as required. If the second pump does not feed, check the lines for plugging. Flush if necessary. If still plugged, check to ensure that the heaters to the lines are working and that the tank heater and mixer are working. Repair as required.

If stirring is not noted in the mixer chamber, check the mixer to ensure that motor is working and repair according to the manufacturer's manual as required. Check to ensure that the impeller is in place and replace if necessary.

E. MIXER BASIN 2

The purpose of Mixer Basin 2 is to mix the ferrous sulfate solution with the sodium sulfide industrial wastewater mixture and to adjust the mixture pH to between 7.2 and 7.5. In this mixer basin, the hexavalent chromium is reduced below NPDES permit requirements of 0.1 mg/liter and precipitation of the chromium hydroxide and metal sulfides is started.

1. Equipment

Mixer Basin 2 is a 13- x 14- x 16-foot concrete tank with an axial flow impeller mixer. Included with the mixer basin is a 5600-gallon insulated and heated ferrous sulfate solution tank with a mixer and two feed pumps (one as a primary and a second one as a standby), one acid feed tank with two acid feed pumps (one as a spare) and a pH probe, monitor, control, and alarm. The monitor, control, and alarm are located in the control room.

2. Normal Operation

a. Operating Strategy

The wastewater flows from Mixer Basin 1 under a baffle into Mixer Basin 2. The baffle serves to prevent backflow into Mixer Basin 1. The ferrous sulfate solution (7.7 percent by weight ferrous sulfate with 200 milliliters H_2SO_4 per 50 gallons) is fed into the mixer basin at the center of the south wall. The required ferrous sulfate concentration is 1.5 mg/liter per 1 mg/liter hexavalent chromium. The ferrous sulfate acts to reduce the hexavalent chromium and as a coagulant. The pH adjustment is required for complete reduction of the hexavalent chromium and provides the optimum pH for coagulation and flocculation. The pH of the mixture is adjusted to between 7.2 and 7.5 with sulfuric acid. The pH probe sends a signal to the controller which turns on the sulfuric acid feed pump as required to maintain this pH.

As with the sodium sulfide feed, the ferrous sulfate concentration and the solution pH is critical to the chromium reduction and the metal removal process. If insufficient ferrous sulfate is fed, chromium will not be reduced. If too much ferrous sulfate is fed, excess iron will be carried through the solids contact clarifier and sludge production will increase, as will the process costs. A pH higher than 7.5 will decrease hexavalent chromium reduction. In addition, as with excess sodium sulfide, a fine black precipitate forms at high pH which cannot be removed at the solid contact clarifier. If the pH is too low, hydrogen sulfide gas will form. The ferrous sulfate feed requirement as a function of the hexavalent chromium concentration and influent flow rate is given in Tables 4 and 5.

The wastewater flows over the west wall of Mixer Basin 2 into Mixer Basin 3.

b. Sampling and Testing

The pH of the mixer basin should be sampled hourly with a portable pH meter to ensure that the pumps and meters are working correctly. The ferrous sulfate feed should be analyzed weekly for ferrous and total iron to ensure that the solution is remaining stable and that iron is not precipitating. The ferrous sulfate feed pumps should be calibrated weekly to ensure proper ferrous feed.

3. Maintenance

Maintenance of Mixer Basin 2 consists of maintaining the mixer in the chamber, the ferrous sulfate chemical feed pumps, the sulfuric acid feed pumps, the chemical feed tank mixer, and the heater. Routine maintenance should be performed according to the manufacturer's manual provided with the equipment.

The mixer basin should be pumped out and cleaned every 3 years. The chamber walls and the bottom should be examined for any cracks or leaks and these repaired. At the same time, the chamber mixer should be checked out according to the manufacturer's instruction and any repair kits installed. The mixer impeller and shaft should be examined at this time for any cracks or signs of excessive wear and, if necessary, repaired.

During cold weather, the chemical storage tank and heat-taped chemical feed line should be checked to make sure the heaters are working properly.

TABLE 4. REQUIRED FEED RATE FOR A FERROUS SULFATE SOLUTION AS A FUNCTION OF IWTP INFLUENT FLOW RATE AND HEXAVALENT CHROMIUM CONCENTRATION (77,000 mg/L Fe).

Cr+6 (mg/L)	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Influent Flow (mgd)	Required Ferrous Sulfate Feed Rate (mL/min)																				
0.10	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	24	25	26
0.15	8	9	11	12	14	15	17	18	20	21	23	25	26	28	29	31	32	34	35	37	38
0.20	10	12	14	16	18	20	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51
0.25	13	15	18	20	23	26	28	31	33	36	38	41	43	46	49	51	54	56	59	61	64
0.30	15	18	21	25	28	31	34	37	40	43	46	49	52	55	58	61	64	68	71	74	77
0.35	18	21	25	29	32	36	39	43	47	50	54	57	61	64	68	72	75	79	82	86	89
0.40	20	25	29	33	37	41	45	49	53	57	61	65	70	74	78	82	86	90	94	98	102
0.45	23	28	32	37	41	46	51	55	60	64	69	74	78	83	87	92	97	101	106	110	115
0.50	26	31	36	41	46	51	56	61	66	72	77	82	87	92	97	102	107	113	118	123	128
0.55	28	34	39	45	51	56	62	68	73	79	84	90	96	101	107	113	118	124	129	135	141
0.60	31	37	43	49	55	61	68	74	80	86	92	98	104	110	117	123	129	135	141	147	153
0.65	33	40	47	53	60	66	73	80	86	93	100	106	113	120	126	133	140	146	153	160	166
0.70	36	43	50	57	64	72	79	86	93	100	107	115	122	129	136	143	150	158	165	172	179
0.75	38	46	54	61	69	77	84	92	100	107	115	123	130	138	146	153	161	169	176	184	192
0.80	41	49	57	65	74	82	90	98	106	115	123	131	139	147	155	164	172	180	188	196	205
0.85	43	52	61	70	78	87	96	104	113	122	130	139	148	156	165	174	183	191	200	209	217
0.90	46	55	64	74	83	92	101	110	120	129	138	147	156	166	175	184	193	203	212	221	230
0.95	49	58	68	78	87	97	107	117	126	136	146	155	165	175	185	194	204	214	223	233	243
1.00	51	61	72	82	92	102	113	123	133	143	153	164	174	184	194	205	215	225	235	245	256
1.05	54	64	75	86	97	107	118	129	140	150	161	172	183	193	204	215	226	236	247	258	268
1.10	56	68	79	90	101	113	124	135	146	158	169	180	191	203	214	225	236	248	259	270	281
1.15	59	71	82	94	106	118	129	141	153	165	176	188	200	212	223	235	247	259	271	282	294
1.20	61	74	86	98	110	123	135	147	160	172	184	196	209	221	233	245	258	270	282	295	307
1.25	64	77	89	102	115	128	141	153	166	179	192	205	217	230	243	256	268	281	294	307	320
1.30	66	80	93	106	120	133	146	160	173	186	199	213	226	239	253	266	279	293	306	319	332
1.35	69	83	97	110	124	138	152	166	179	193	207	221	235	249	262	276	290	304	318	331	345
1.40	72	86	100	115	129	143	158	172	186	200	215	229	243	258	272	286	301	315	329	344	358
1.45	74	89	104	119	133	148	163	178	193	208	222	237	252	267	282	297	311	326	341	356	371
1.50	77	92	107	123	138	153	169	184	199	215	230	245	261	276	291	307	322	338	353	368	384

TABLE 5. EXAMPLES OF FERROUS SULFATE FEED PUMP SETTINGS AS A FUNCTION OF SULFATE FEED REQUIREMENTS.

Ferrous Sulfate (mL/min)	30 % Stroke (SPM)	50% Stroke (SPM)	70% Stroke SPM
10	1	1	0
20	2	2	0
30	3	2	2
40	4	3	3
50	6	4	3
60	7	5	4
70	8	5	4
80	9	7	5
90	10	7	6
100	11	8	6
110	12	9	7
120	13	9	8
130	14	10	8
140	16	11	9
150	17	12	10
160	18	13	10
170	19	13	11
180	20	14	12
190	21	15	12
200	22	16	13
210	23	15	13
220	24	17	14
230	25	18	15
240	27	19	15
250	28	19	16
260	29	20	17
270	30	21	17
280	31	22	18
290	32	23	19
300	33	23	19
310	34	24	20
320	35	25	20
330	37	26	21
340	38	27	22
350	39	27	22
360	40	28	23
370	41	29	24
390	43	31	25
400	44	31	26
410	45	32	26
420	47	33	27
430	48	34	27
450	50	35	29
460	51	36	29
470	52	37	30
480	53	37	30
490	54	38	31
500	55	39	32

4. Primary Duties of the Shift Operator

- Consult with the previous shift operator to determine (a) results of previous tests and samples. (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- During freezing weather, check the operation of the ferrous sulfate and sulfuric acid storage tanks and piping heaters.

- Check the operation of the mixer, the ferrous sulfate and sulfuric acid feed systems, and the pH control system.

- Review the plant flow rate, hexavalent chromium concentration, sodium sulfide dosage rate, and the planned ferrous sulfate dosage rate.

- Verify that the correct ferrous sulfate dosage rate is being used.

- Check the level in the ferrous sulfate and sulfuric acid storage tanks and reorder when appropriate.

- Manually measure and record the pH in Mixer Basin 2 hourly.

- Clean and calibrate the pH probe daily.

5. Startup Procedures

To start up Mixer Basin 2, influent must be flowing from Mixer Basin 1. Start the mixer, open the chemical feed valves (acid and ferrous sulfate), and turn on the chemical feed pumps. Set the ferrous sulfate feed pump to the proper rate according to the hexavalent chromium concentration and influent flow rate. Set the acid feed controller.

6. Shutdown Procedure

To shut down the mixer basin, close the wastewater inlet valve, shut off the chemical feed pump, and then shut the chemical feed valves. Pump the wastewater from the mixer basin, either to Mixer Basin 3 or to a tank truck. If the ferrous sulfate feed tank is to remain full, the tank mixer and heaters should remain on. Otherwise, the ferrous sulfate should be pumped out of the tank, the heaters and mixers shut off, the tank flushed out, and the chemical feed lines drained.

7. Abnormal Occurrences

If ferrous sulfate is not being fed, start the standby chemical feed pump and set at the required feed rate. Check to make sure the pump is feeding ferrous sulfate. An indication of a lack of ferrous sulfate feed is a yellow or light color in the mixer basin. If this is the case, check the failed chemical pump according to the manufacturer's instruction and repair as required. If the second pump does not feed, check the lines for plugging. If plugging occurs, check to ensure that line heaters, tank heater, and mixer are working. Repair as required.

If stirring is not apparent in the mixer basin, check the mixer to ensure that the motor is working, and repair according to the manual. Check to ensure that the impeller is in place and replace as required.

If the pH is high in the mixer basin, start the second acid feed pump and make sure the acid is feeding. If it is, check the failed pump according to the manufacturer's instructions and repair as required. If neither pump feeds the sulfuric acid, check the lines for plugging. Flush if required. If the pH is low or high, check the pH probe, the portable meter, and the controller according to the manufacturer's manuals and repair or replace as required.

F. MIXER BASIN 3

The purpose of Mixer Basin 3 is to mix the cationic polymer with the wastewater to initiate flocculation of the metal precipitates.

1. Equipment

Mixer Basin 3 is a concrete tank (9 foot x 9 foot x 10 feet-6 inches), which contains an axial-flow impeller mixer. Included with the system is a 2000-gallon insulated heated storage tank for the liquid polymer, a polymer mixing feed system, a streaming current detector (zeta meter) for controlling the polymer feed, and an instrument panel-mounted recorder.

2. Normal Operation

a. Operating Strategy

The wastewater flows from Mixer Basin 2 into the mixer basin. The cationic polymer, Betz 1195^R diluted to 5 percent, is fed over the top into the center of the chamber near the mixer. The solution flows by gravity from the bottom of the chamber to the solids contact clarifier.

The liquid cationic polymer feed system includes a tank, slow speed mixer, and level indicator to control feed of the neat polymer. The polymer is pumped from the bulk storage tank to a 250-gallon stainless steel mixing tank supplied with a continuous domestic water flow. The water flow is maintained at 0.5 gpm. This flow controls the feed of the neat polymer. The solution is pumped from the bottom of the dilution mixer tank to Mixer Basin 3. The polymer feed rate from the dilution tank is controlled by the streaming current detector. A wastewater sample (2 liters/min) is pumped from the effluent line of the mixer basin to the detector. The detector indicates the electrokinetic charge of the water after polymer addition. The polymer is fed so that the charge is maintained slightly positive (two units) at the streaming current detector. This charge allows the cationic polymer to work effectively as a flocculant. A higher positive potential is not desirable since there is little change in flocculation effectiveness as a function of polymer concentration after a positive charge is reached.

b. Sampling and Testing

Not applicable.

3. Maintenance

Maintenance of Mixer Basin 3 consists of maintaining the mixer in the chamber, the polymer chemical feed system, the streaming current detector, and pump. Routine maintenance should be performed according to the manufacturer's manuals.

The mixer chamber should be pumped out and cleaned every 3 years. The chamber walls and the bottom should be examined for any cracks or leaks and these repaired. At the same time, the mixer basin should be inspected according to the manufacturer's instructions and any repair kits installed. The mixer impeller and shaft should be examined at this time for any cracks or sign of excessive wear, and repaired if necessary.

During cold weather, the polymer storage tank and heat-taped lines should be checked daily to make sure the heaters are working properly.

4. Primary Duties of the Shift Operator

- o Consult with the previous shift operator to determine (a) results of previous tests and samples,(b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- o During freezing weather, check the operation of the cationic polymer storage tank and piping heaters.

- o Check the operation of the mixer, cationic polymer feed system, and the streaming current detector water system.

- Check the domestic flow rate to the cationic polymer dilution tank. (Note: the viscous cationic polymer cannot pump if the water flow rate is greater than 0.5 gpm. This maximizes the polymer feed pump. At this rate, the pump does not allow flow of the polymer into the pump between strokes.)

- Check the operation of the automatic controller for preparing the dilute cationic polymer feed solution.

- Check the level in the cationic polymer storage tank and reorder when appropriate.

5. Startup Procedure

Open the valves to the bulk polymer storage and the domestic water supply. Start the automatic controller for the dilute polymer feed tank. Start the polymer feed pump. When wastewater is flowing from Mixer Basin 3 into the SCC, start the streaming current detector sample pump, and set the controller.

6. Shutdown Procedure

To shut down Mixer Basin 3, shut off the flow from the equalization tank, the bulk polymer storage, the domestic water, the mixer, the automatic controller for preparing the dilute polymer feed solution, the streaming current detector, and the sample pump. Drain the polymer mixing tank and polymer feed lines, and pump out and check the mixer chamber. Make sure that the polymer feed line is closed.

7. Abnormal Occurrences

If the streaming current is not at the required value, check to see if the polymer is feeding. Check the domestic water flow rate to ensure a flow of at least 0.5 gpm. Repair as required.

Mixing is critical to optimize floc formation. If stirring is not noted in the mixer chamber, check the mixer to ensure that the motor is working and repair according to the manufacturer's manual as required. Check to ensure that the impeller is in place and replace as required.

G. SOLIDS CONTACT CLARIFIER

The purpose of the solids contact clarifier is to flocculate and settle the precipitated metals.

1. Equipment

The solids contact clarifier (SCC) is located in a 55 foot diameter tank with a floor slope of 1/2 to 12 inches. The SCC includes a 2-foot 6-inch diameter center pier/influent pipe, which discharges the influent into the center of the mixing chamber, which is 14 feet in diameter with a 6-foot side wall depth. Surrounding the mixing chamber is a flocculation skirt, which is 18 feet in diameter at the top, 33 feet in diameter at the bottom, and is 7 feet 6 inches deep. Mechanical equipment includes a two-arm sludge rake which rotates at 0.042 rpm, a rotating skimmer mechanism with a scum collection box, and an internal sludge recirculation pump. Ancillary equipment includes two external sludge recirculation pumps, two external sludge wasting pumps, and an anionic polymer feed system. The SCC is shown schematically in Figure 3.

Liquid and particulates from Mixer Basin 3 flow by gravity through the center pier/influent pipe into the mixing chamber of the SCC. Anionic polymer is fed by a metering pump into the mixing chamber to assist particulate flocculation. Sludge from near the floor of the SCC is drawn up through the internal sludge recirculation pump into the mixing chamber to increase the suspended solids concentration and provide energy for mixing and flocculation. Sludge from the sludge hoppers is returned through an external pipe by the external sludge recirculation pumps into the mixing chamber to further increase the suspended solids concentration in the mixing chamber and flocculation skirt.

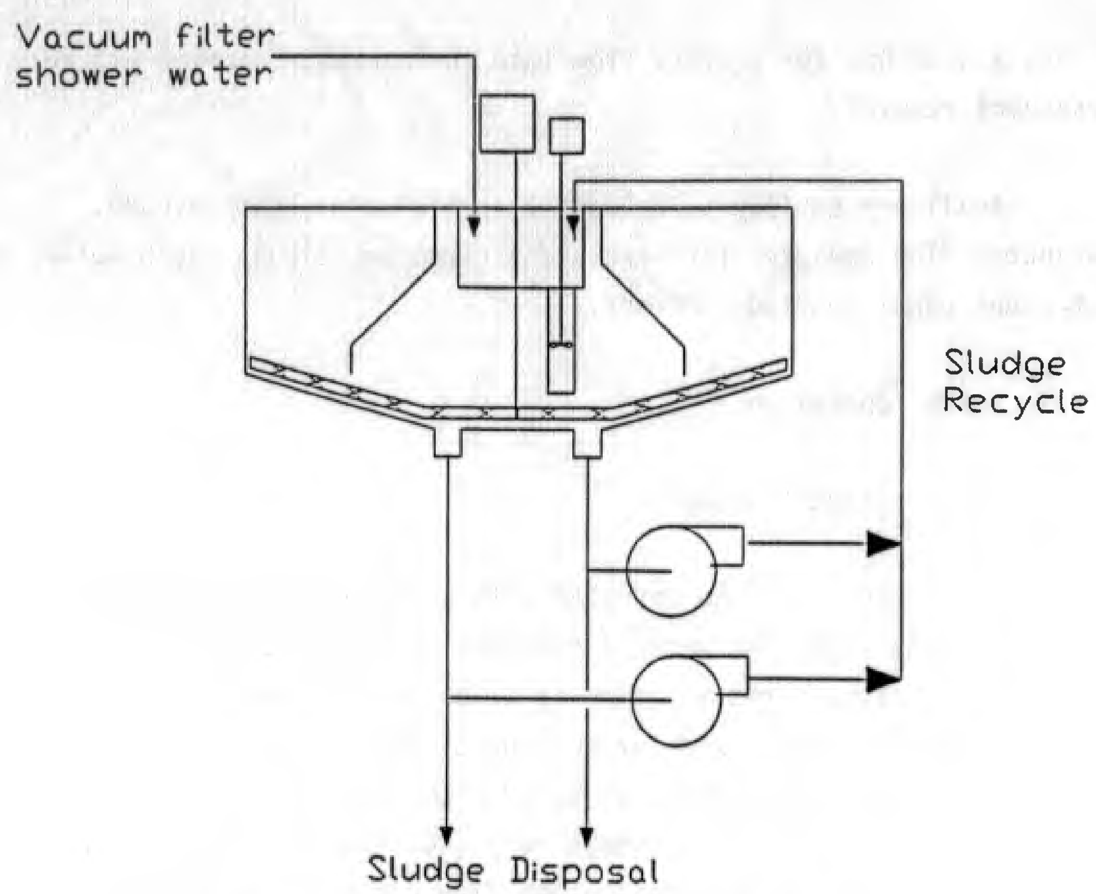

Figure 3. Solids Contact Clarifier.

Liquid from the mixing chamber flows into the top of the flocculation skirt through adjustable tangential slanted gates, which impart a rotating motion to the water entering the flocculation skirt. This rotating motion gradually decreases as the flow proceeds downward through the flocculation skirt, providing tapered flocculation energy. The liquid flows out from under the flocculation skirt, allowing the well-flocculated particles to settle to the floor while the water moves upward towards the liquid surface, under a scum baffle and over the peripheral collection weirs into the effluent trough, and into the primary lift station wet well.

Floatable matter in the liquid rises to the SCC liquid surface where a scum baffle prevents its escape over the effluent weirs. The rotating skimmer arm collects the matter on the liquid surface and forces it into a scum box for gravity flow into an internal concrete pit for subsequent removal.

Auxiliary equipment includes a turbidimeter, sample pump, continuous flow analyzer for hexavalent chromium, sludge depth meter, and instrument panel-mounted recorder.

2. Normal Operation

a. Operating Strategy

The SCC is to be operated with an anionic polymer dosage rate of 0.5 mg/L. Betz 1120, the anionic polymer, is obtained in bulk as a powder. The polymer feed solution is to be made up daily according to Table 6, and should be mixed for 60 minutes before use. The chemical metering pump must be manually adjusted each time the flow rate is changed to maintain the 0.5 mg/liter dosage rate (see Table 7 for the required polymer feed rates for different plant flow rates). The feed solution deteriorates with time, and should not be used after 24 hours.

The internal sludge recirculation pump should be run continuously. This pump is currently driven by a constant speed drive. External sludge recirculation pumps should be run as required to maintain the desired concentration of suspended solids in the mixing chamber. Measure the suspended solids concentration as percent suspended solids by volume after 5 minutes of settling. To do this, collect a representative sample from the mixing chamber in a 100-milliliter graduated cylinder, let settle for 5 minutes, and read the volume of solids that have settled. This type of SCC has been found to perform well with suspended solids concentration in the 10-20 percent range. However, pilot testing and startup of this process indicated that performance continued to improve with suspended solids concentration up to 90 percent.

The two external sludge recirculation pumps are controlled by individual manual-off-automatic switches. In the manual mode, either, or both pumps will run continuously. In the automatic mode, the pump or pumps are controlled by a timer, which has a 4- to 30-minute on time and a 4- to

TABLE 6. MAKEUP OF BETZ 1120 ANIONIC POLYMER SOLUTION

Makeup Volume (Gal)	1120 Weight (Grams)
5	95
10	190
15	285
20	380
25	475
30	570
35	665
40	760
45	855
50	950
55	1045
60	1140
65	1235
70	1330
75	1425
80	1520
85	1615
90	1710
95	1805
100	1900
105	1995
110	2090
115	2185
120	2280
125	2375
130	2470
135	2565
140	2660
145	2755
150	2850
155	2945
160	3040
165	3135
170	3230
175	3325
180	3420
185	3515
190	3610
195	3705
200	3800
205	3895
210	3990
215	4085
220	4180
225	4275

TABLE 7. BETZ 1120 ANIONIC POLYMER FEE RATE AS A FUNCTION OF IWTP INFLUENT FLOW RATE.

IWTP Flow (gpd)	Polymer Flow (mL/min)	Volume (gal/day)	IWTP Flow (gpd)	Polymer Flow (mL/min)	Volume (gal/day)
0.10	26	10	1.04	273	104
0.12	32	12	1.06	278	106
0.14	37	14	1.08	284	108
0.16	42	16	1.10	289	110
0.18	47	18	1.12	294	112
0.20	53	20	1.14	299	114
0.22	58	22	1.16	305	116
0.24	63	24	1.18	310	118
0.26	68	26	1.20	315	120
0.28	74	28	1.22	320	122
0.30	79	30	1.24	326	124
0.32	84	32	1.26	331	126
0.34	89	34	1.28	336	128
0.36	95	36	1.30	341	130
0.38	100	38	1.32	347	132
0.40	105	40	1.34	352	134
0.42	110	42	1.36	357	136
0.44	116	44	1.38	362	138
0.46	121	46	1.40	368	140
0.48	126	48	1.42	373	142
0.50	131	50	1.44	378	144
0.52	137	52	1.46	383	146
0.54	142	54	1.48	389	148
0.56	147	56	1.50	394	150
0.58	152	58			
0.60	158	60			
0.62	163	62			
0.64	168	64			
0.66	173	66			
0.68	179	68			
0.70	184	70			
0.72	189	72			
0.74	194	74			
0.76	200	76			
0.78	205	78			
0.80	210	80			
0.82	215	82			
0.84	221	84			
0.86	226	86			
0.88	231	88			
0.90	236	90			
0.92	242	92			
0.94	247	94			
0.96	252	96			
0.98	257	98			
1.00	263	100			
1.02	268	102			

30-minute off time. In this on/off mode either or both pumps may be run or they can alternate. The frequency of alternation is set on the counters which count the number of times a pump is on, then switches to the other pump when the preset count is reached.

The suspended solids concentration in the mixing chamber is controlled by the amount of external sludge recirculation pumping. Increasing the amount of external sludge recirculation pumping, by increasing the number of pumps in operation and/or the daily duration of pumping, increases the suspended solids concentration in the mixing chamber. The increase in suspended solids concentration is limited by the total amount of solids present within the SCC. For a given amount of solids, there is a maximum concentration of suspended solids possible. Further increases in suspended solids concentration is possible only by increasing the solids inventory in the SCC. The solids inventory can be increased by reducing the amount of sludge wasting from the SCC.

The intensity of flocculation is controlled by the position of the tangential gates on the mixing chamber. These should be positioned to provide a difference in the water level inside and outside of the mixing chamber of between 1 and 4 inches. The positioning should also provide a relatively equal flow split between the six ports.

Sludge is wasted from the SCC by pumping from the two waste sludge pumps to the sludge thickener. The sludge pumps were originally installed, and are still used, to pump thickened sludge from the sludge thickener tank to the sludge dewatering filter. Piping modifications have been made to allow the SCC sludge to be pumped to the sludge thickener by proper valve positioning. The pumps are controlled manually.

The sludge level controlled by the amount of sludge wasting, is to be maintained at a depth of about 10 feet at the center of the catwalk. The manufacturer recommends that the sludge level be kept below the bottom of the flocculation skirt. However, the pilot testing of this process, in which a representative of the SCC manufacturer participated, indicated greatly improved clarification performance with the sludge level above the bottom of the sludge skirt. This additional sludge makes a higher suspended solids concentration possible in the mixing chamber and results in increased flocculation. The sludge depth can reach approximately 12 feet before solids are carried over with the effluent with the motion of the sludge rake. It is better to maintain 10 feet. This is approximately 3 feet above the bottom of the flocculation skirt and allows for a decrease in depth with decreased flow. The sludge level (bed) also serves as a filter for removing fines from the effluent flow.

b. Sampling and Testing

Daily sampling of the mixing well and effluent, and determination of the sludge level are required. A 100-milliliter sample from the mixing well is to be settled for 5 minutes in a 100-milliliter graduated cylinder. The volume of settled solids (SS) is recorded as percent SS by volume.

The sludge level is determined by use of a core-type sampler tube such as a Sludge Judge.™ The level should be measured at the flocculation skirt. The sample location must be recorded along with the depth.

The SCC effluent turbidity is measured on a continuous flow turbidimeter and recorded on a continuous strip chart. Changes in turbidity are the quickest and easiest way to identify needed changes in the SCC treatment. Limits on the pilot plant showed metal removal to below NPDES permit requirement with a turbidity of 8 to 16 Nephelometric Turbidity Units (NTU).

The anionic polymer powder and the polymer inductor tube should be kept dry. Any polymer that collects in the tube due to high humidity should be cleaned out.

3. Maintenance

Follow the manufacturer's instructions in the maintenance of all SCC equipment, including the SCC drive and internal sludge recirculation pump, the polymer feed system, and turbidimeter as well as the external sludge recirculation pumps and sludge wasting pumps. The SCC tank should be drained and cleaned every three years for inspection, cleaning, and any needed repairs and painting. Sludge lines and valves should be thoroughly inspected and any needed repairs made.

4. Primary Duties of the Shift Operator

- o Consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- o During freezing weather, check the operation of the local chemical feed building and piping heaters.

- o Check the operation of the:

  Clarifier mechanism.

  Internal sludge recirculation mixer.

  External sludge recirculation pumps and controls.

  Anionic polymer feed system.

  Continuous flow analyzer (CFA).

  Continuous flow turbidimeter.

- o Review the plant flow rate and verify that the anionic polymer dosage rate is correct.

- o Check the level in the anionic polymer feed tank and prepare a new batch when required.

- o Check the inventory of powdered anionic polymer and reorder when required.

- o Measure the sludge level in the clarifier.

- o Measure the solid concentration, by volume, in the mixing well of the SCC.

5. Startup Procedures

Startup procedures for the SCC cover two separate conditions: (a) startup of an empty SCC, and (b) startup of the SCC after a temporary shutdown when sludge is still present in the tank from previous operation.

a. Startup of an Empty SCC

- o Go through the mechanical prestart check as described in the manufacturer's operating instruction.

- o Introduce flow into the SCC tank and start the polymer feed system.

- o Start the collector mechanism drive.

- o When the water level reaches the top of the mixing chamber ports, start the internal sludge recirculation pump and the external sludge recirculation pump(s).

- o When the SCC tank is full and there is flow leaving the tank over the peripheral weirs, start the continuous flow turbidimeter, continuous flow analyzer, sample pump, and meter.

b. Startup of an SCC That Contains Water and Sludge

- o Start the collector mechanism drive.

- o Start the external sludge recirculation pump(s) and the internal sludge recirculation pump.

- Introduce flow into the SCC tank and start the polymer feed system.

- When there is flow over the peripheral weirs, start the continuous flow turbidimeter, sample pump, and meter.

6. Shutdown Procedures

The shutdown procedures for the SCC cover two conditions: (a) temporary shutdown when the tank can be left full of water and sludge, and (b) long-term shutdown when the tank must be emptied.

a. Temporary Shutdown:

- Shut down the continuous flow turbidimeter system.

- Stop the flow into the SCC tank and shut down the polymer feed system.

- Stop the internal sludge recirculation pump.

During a temporary shutdown, the external sludge recirculation pump(s) and the SCC collector mechanism will remain in operation to prevent excessive sludge compaction and/or clogging of the sludge withdrawal lines.

b. Long-Term Shutdown

- Shut down the continuous flow turbidimeter.

- Stop the flow into the SCC tank and shut down the polymer feed system.

- Stop the internal sludge recirculation pump and the external sludge recirculation pump(s).

- Waste sludge through the waste sludge pumps to the sludge thickener. This may have to be done intermittently towards the end of the procedure when the sludge is being moved toward the sludge hoppers only by the collector mechanism.

- Finish draining the tank through the external sludge wasting pumps.

- Stop the collector mechanism.

7. Abnormal Occurrences

In short shutdown when the SCC must be drained, the sludge should be pumped into a storage tank for reuse when starting up the SCC. The sludge should then be pumped into the SCC while filling to establish a sludge blanket. Any mechanical problems with the collector drive mechanism, internal or external sludge recirculation pumps, sludge wasting pumps, polymer feed system, or continuous flow turbidimeter should be repaired in accordance with the manufacturer's instructions.

Excessively high SCC effluent turbidity may be caused by the following:

- Insufficient suspended solids concentration in the mixing chamber. This is corrected by increasing the external sludge recirculation or by decreasing the sludge wasting to increase the sludge inventory.

- Insufficient sludge depth is corrected by increasing the external sludge recirculation or by decreasing sludge wasting to increase the sludge inventory.

- Incorrect chemistry in the chrome reduction process is corrected when the pH, ferrous sulfate to hexavalent chromium ratio, and the sulfide to hexavalent chromium ratio are in the correct ranges as described previously in the chrome reduction process at Mixer Basins 1 and 2 (see also Table 2).

- o Incorrect polymer feed rates are corrected by making sure that the cationic polymer that is fed into Mixer Basin 3 is being properly controlled by the streaming current detector as described previously, and that the anionic polymer is being fed at 0.5 mg/L. The correct preparation method, feed strength, and useful life of the polymers are described by the manufacturer.

- o Sludge depth greater than 12 feet allows carryover of the solids. This is corrected by wasting sludge.

H. PRIMARY LIFT STATION

The purpose of the primary lift station is to transfer the effluent of the solids contact clarifier to the softener basins.

1. Equipment

The major equipment in this system consists of three Crane Deming lift pumps. Their capacities are as follows:

Pump No. 1 - 830 gpm at 29 feet TDH
Pump No. 2 - 1575 gpm at 26 feet TDH
Pump No. 3 - 830 gpm at 33 feet TDH

2. Normal Operation

a. Operating Strategy

The primary lift station is designed to pump wastewater to the softener basins at a flow rate equal to the clarified overflow from the solids contact clarifier. This is accomplished using a level control system that adjusts a throttling valve on the pump discharge in order to maintain a set level. The system is controlled by a level indicator/controller (LIC-1002) located on the main control panel. This instrument has a scale that reads from 0 to 120 inches. A scale reading of 0 corresponds to the elevation of the suction bell on the lift pumps. The controller is provided with a switch that allows automatic or manual operation.

When placed in the manual (MAN) position, the position of the throttling valve on the lift pump discharge can be adjusted by turning the bottom thumb wheel to the "OPEN" or "CLOSE" position. Opening the valve increases flow and closing the valve reduces flow. The actual level in the wet well will be displayed by the right-hand bar, which is red. The status of the throttling valve will be displayed on a meter at the bottom of the controller in terms of percent open (0-100 percent). When placed in the automatic (AUTO) position the controller will automatically adjust the throttling valve to maintain a set level in the wet well. The operator must dial the desired wet well depth using the "SET" thumb wheel located on the left side of the controller. The set point will be displayed by an orange vertical bar on the left side of the depth scale. In the AUTO mode, the actual level of the wet well will be displayed by the red vertical bar.

High and low level alarm circuits are included in the level control system. These alarms are activated when the level in the wet well reaches a low of 36 inches or a high of 102 inches. Each of these alarms is visually displayed at the top of the main control panel. A level switch has been provided that will activate Lift Pump No. 1 or No. 3 if the level in the wet well reaches the high level alarm point.

Although the primary lift station is designed for both automatic and manual operation, it should normally be operated in the automatic mode with a SET level of 78 inches for the wet well depth.

b. Sampling and Testing

No sampling or testing is required at the primary lift station.

3. Maintenance

There are no special maintenance requirements for the equipment in this system other than usual preventive maintenance procedures for pumps and control equipment.

4. Primary Duties of the Shift Operator

- o Consult with the previous shift operator to determine (a) operating strategies currently in use, and (b) operating status of all electrical and mechanical equipment.

- o Check the level controller to make sure the set level in the wet well is being maintained.

- o Check the operation of the pumps and control valve.

5. Startup Procedure

- o Open the suction and discharge valves on the pump or pumps being put into service.

- o Place the circuit breakers for the pump or pumps being put into service in the "ON" position.

- o Set the level indicator/controller as needed at the main control panel. See the Operating Strategy section above for a discussion of this control.

6. Shutdown Procedure

- o Place circuit breakers to the pump or pumps being taken out of service in the "OFF" position.

- o Close suction and discharge valves on the pump or pumps being taken out of service.

7. Abnormal Occurrences

Mechanical failure of the pumps or controller should be repaired in accordance with the manufacturer's instructions.

If the automatic mode should fail to operate properly, the manual mode can be used in an emergency. When operating in the manual mode, the operator should adjust the percent opening of the throttling valve until the red vertical bar indicates a stable level in the wet well. The operator must check the level (red bar) frequently and change the throttling valve opening as necessary to maintain a constant level.

I. SOFTENER BASINS

The softener basins were included in a previously used process requiring the use of soda ash for noncarbonate hardness softening. With the sodium sulfide/ferrous sulfate process, the water hardness is nominally 150 mg/liter calcium carbonate, or $CaCO_3$, which is within the requirements for reclaimed water. The softener is not required by this process, but can serve as additional clarifier ahead of the activated sludge system.

1. Equipment

The softener basins consist of two side-by-side tanks nominally 11 x 62 x 11 feet deep. They include a flocculation area with variable speed flocculators, an intermediate section for flow direction and distribution, and a third section for clarification and solids removal.

In this section, flocculated solids separate from the flowing water and settle to the bottom of the basin. A flight conveyor pushes the settled solids or sludge to a hopper located at the bottom of the basin at the effluent end of the clarifier.

2. Normal Operation

For the sodium sulfide/ferrous sulfate process only the clarification section is used; the flocculator drives are turned off. In the clarifier section, solids carried over from the solids contact clarifier separate from the upward flowing water and settle to the bottom of the basin. A flight conveyor pushes the settled solids or sludge to a hopper located in the bottom of the basin at the effluent end of the clarifier.

Sludge is removed from the sludge pit through a 2-inch motor-operated valve, which is timer activated. Both the frequency and the period of the sludge draw-off can be set. These timer settings should be determined by collecting and analyzing sludge draw-off samples. Samples should be collected at the beginning and the end of a draw-off period. If the average sludge concentration during the period is less than 3 percent by weight, the frequency of draw-off should be decreased.

The clarified water is removed from the basin over two weirs into an outlet box at the effluent end of the clarifier and leaves the box through a 12-inch diameter connection.

Before the clarified water enters the weirs, it passes upward through settler tubes located beneath the weirs. The settler tubes cover the entire area of the clarifier basin, and enhance the removal of any suspended particles.

3. Maintenance

Follow normal maintenance procedures specified by the equipment manufacturer. In addition, since the flocculator drives are not in regular use, they should be run for 30 minutes per week. If operating experience indicates that the flight conveyors are not usually required, they should also be run for 30 minutes per week.

Each basin should be drained and flushed annually and inspected for deterioration of the coatings or wear on the chain and sprockets. Additional cleaning of the weirs and weir troughs may be required to remove deposits.

4. Startup Procedure

The discharge lines should be opened before startup. The sludge blowdown lines should be clear, and the valves, operators, and timers checked for normal operation. All drives should be engaged and inspected for proper function and clearances. Then open inlet valves to both tanks and split the flow equally between the two tanks.

5. Shutdown Procedure

When danger of freezing exists and the basins are not in service, the wastewater must be drained to prevent damage to the weirs and settler tubes.

6. Abnormal Occurrences

Abnormal occurrences are limited to mechanical failure of chains, sprockets, or automatically-activated sludge blowdown valves. Typically, failed chains cause mechanism jamming and system shutdown. Excess or continuous liquid flow to the sludge thickener may indicate a failed-open blowdown valve.

Leaks may periodically develop around the flight conveyor drives, which indicates worn seals at the tank feed trough. For repair of this and other items noted, refer to the equipment manufacturer's literature.

J. ACTIVATED SLUDGE SYSTEM

The activated sludge system, or biological treatment system, removes soluble organic food (primarily phenol) from the wastewater by using this food to grow, reproduce, and form other byproducts. This process reduces the oxygen demand of the wastewater.

1. Equipment

The major equipment associated with this system includes the aeration basins, two secondary clarifiers, and two auxiliary feed systems. The aeration system contains two parallel operated concrete basins that are 70 feet long by 20 feet wide, with an 18-foot side water depth, and 4-foot freeboard. Each basin holds about 190,000 gallons. Aeration and mixing are provided by a static aeration system consisting of two 968 scfm centrifugal blowers and 48 static aerators located on 8-foot centers (24 inches from the bottom of each basin).

Two auxiliary feed systems are used to add nitrogen (as ammonia) and phosphate (as phosphoric acid) to the wastewater before it enters the aeration basins. These two systems feed into the aeration basin influent line upstream of a 16-inch static in-line mixer. The ammonia feed system consists of a 1250-gallon anhydrous ammonia storage tank and instruments to regulate the ammonia feed rate. The system can feed up to 50 pounds/day. The phosphoric acid feed system's metering pump can deliver up to 20 gph of 85% phosphoric acid.

The secondary clarifiers consist of one suction-type clarifier, 45 feet in diameter, and a one plow type unit, 55 feet in diameter. The clarifiers are operated in parallel with flow to each unit proportioned by a weir box at the outlet of the aeration basins. Included as part of the secondary clarifiers is a secondary sludge pumping station that contains four return activated sludge (RAS) pumps. These pumps, each rated at 400 gpm, take settled solids and liquids from the bottom of the secondary clarifiers and recycle them to the inlet of the aeration basins. Two of the pumps service the larger secondary clarifier and two service the smaller clarifier. The pumps share a common discharge line which contains a flow control system for regulating the total flow being returned to the activated sludge basin. A portion of the returned sludge can be sent to the gravity sludge thickener to waste it from the system.

2. Normal Operation

a. Operating Strategy

The wastewater flows by gravity from the softener tanks to the activated sludge tanks. Before entering the tanks, the wastewater is mixed with the RAS that has been pumped from the bottom of the secondary clarifiers. At this point, ammonia and phosphoric acid phosphate are also mixed with the wastewater, which is split equally between the two activated sludge tanks. The flow passes through the tanks and is then proportionally distributed between the two secondary clarifiers. In the secondary clarifiers, the solids (sludge) settle to the bottom and are pumped back into the process while the clear upper liquid flows over the weirs to the chlorine contact chamber.

The activated sludge process uses microorganisms to remove organic materials (primarily phenols) from the waste water by converting into new biomass and degradation byproducts. The mixture of organisms and waste water is subjected to intense aeration for 6 to 12 hours, depending on flow rate, then sent to a secondary clarifier where the organisms (activated sludge) are removed from the liquid. The settled activated sludge is returned to the inlet of the aeration basin to mix with the incoming waste water. Excess activated sludge is wasted to the sludge thickener. Proper management of the amount of returned activated sludge is the key to an efficiently operating biological system.

The activated sludge requires oxygen and food. In addition, certain nutrients (nitrogen and phosphorus) must be present to support cell growth. A healthy activated sludge is best developed and maintained under steady-state conditions with no sudden changes in environment or loading. The purpose of the blending and equalization tanks is to provide as uniform feed to the entire treatment process. Proper operation of the blending and equalization tanks is therefore critical to maintaining the stable operation of the activated sludge system.

Conditions favoring healthy activated sludge are: a neutral pH, a temperature above 60°F, sufficient dissolved oxygen to maintain a residual of about 1 to 2 mg/L, adequate food or substrate, elimination of wastes not readily utilized as food, and the absence of phenol shock loads. Since removing BOD_5 results in the generation of solids, a portion of the settled sludge must be wasted to the sludge thickener in order to maintain the proper mixed liquor volatile suspended solids (MLVSS) level in the aeration basin.

The effectiveness of the activated sludge process in removing organic matter depends on maintaining a proper balance between waste loading (food) and activated sludge (biomass in the treatment basin. The two most important parameters for controlling the activated sludge system are the food to mass ratio (F/M) and the mean cell residence time (MCRT). These, and other important parameters that must be monitored, are described below.

(1) Food to Mass Ratio. The most effective way to control the activated sludge process is to maintain a constant F/M ratio in the aeration basins. The amount of food present can be estimated by measuring the phenol and TOC or COD concentration of the wastewater entering the process. The optimum value of the F/M ratio must be determined through experience, and good plant operation records must be maintained to define the optimum parameters required to maintain efficient treatment.

The activated sludge process was designed for a food input rate of 1400 pounds of BOD_5 per day and a F/M ratio of 0.15 pounds of BOD_5 per day per pound of MLVSS. With this input of food, the MLVSS concentration in the aeration basins should be maintained in the range of 2000 to 4000 mg/L.

In practice, this method of control may be difficult without enough advance warning of phenol loading changes to permit system adjustments. Therefore, it is extremely important that the blending and equalization tanks be operated so as to provide conditions as constant as possible.

(2) Mean Cell Residence Time. The MCRT should be closely monitored and controlled. To calculate the MCRT, use the following formula:

$$\text{MCRT (days)} = \frac{\text{Suspended Solids in Total Secondary System (lb)}}{\text{Suspended Solids Wasted (lb/day)} + \text{Suspended Solids Lost in Effluent (lb/day)}}$$

The normal range of MCRT for a long aeration process such as the one at Tinker AFB is 20 to 30 days; 25 days should be used as an initial target. To apply the equation, the following parameters must be measured:

- o MLSS concentration.
- o Total system volume; aeration basins and secondary clarifiers.
- o Return activated sludge (RAS) suspended solids (SS) concentration
- o Average daily waste activated sludge (WAS) flowrate.
- o Clarifier effluent SS concentration.
- o Plant flowrate.

For example, the MCRT is calculated below using values typical at Tinker AFB IWTP

MLSS concentration	= 3,300 mg/L
Total system volume	= 0.69 MG
RAS SS concentration	= 8,500 mg/L
Average daily SAS flowrate	= 0.010 MGD (7 gpm)
Clarifier effluent SS concentration	= 20 mg/L
Plant flowrate	= 0.80 MGD

$$\text{MCRT} = \frac{3300 \text{ mg/L} \times 0.69 \text{ MG}}{(8500 \text{ mg/L} \times 0.010 \text{ MGD}) + (20 \text{ mg/L} \times 0.8 \text{ MGD})}$$

MCRT = 22.5 days

Since the calculated MCRT, 22.5 days, is lower than the target MCRT, 25.0 days, the sludge wasting rate should be decreased to 0.0086 MGD (6 gpm) to increase the pounds of suspended solids in the biological system and thus increase the MCRT. Since it is impossible to predict the MCRT that will produce the best plant performance, the target value should be periodically adjusted in small increments until the operating range that produces the highest quality effluent is found.

Sludge is wasted from the biological system by periodically diverting a portion of the recycled sludge flow to the thickener. The flow rate of waste activated sludge (WAS) is adjusted by a control located on the main control panel. The scale on this unit is calibrated for 0 to 20 gpm. Normally, this controller should be set on the "AUTO" position using the switch at the bottom of the unit. The left hand (orange) bar is adjusted to the proper WAS flow rate using the thumb wheel. The right hand (red) bar will indicate the actual WAS flow rate. If operating properly, the red and orange bars will read roughly the same flow rate.

If necessary, the sludge waste rate can be manually controlled by placing the unit in the "MAN" position. In this mode, the bottom thumb wheel is used to adjust the WAS flowrate (the red bar) to the desired flowrate.

(3) Sludge Volume Index (SVI). Determining the SVI is described later in this section. When the SVI falls much below 75, the sludge is settling so rapidly that poor clarification will result. This condition often indicates that the sludge is too old and that the sludge wasting rate needs to be increased. When the SVI increases above 200, it may be the result of a young sludge or bulking sludge, which settles very slowly. Other causes may include low pH or an insufficient amount of dissolved oxygen. Corrective measures for this condition include decreasing the sludge wasting rate, increasing the sludge recycle rate, and/or raising the pH or increasing the amount of dissolved oxygen.

(4) Return Activated Sludge (RAS) Flow Rate. One of the primary control mechanisms for the biological process is the RAS flow rate. The RAS flow rate, which affects both the F/M and the MCRT, is

adjusted using the flow controller located on the main control panel. The scale on this unit reads from 0 to 1600 gpm. With the unit in the AUTO mode, the desired flow rate is set by adjusting the thumb wheel until the left hand (orange) bar is at the desired value. The right hand (red) bar indicates the actual flowrate.

The RAS flow rate is normally set at 50 to 100 percent of the plant flow. For example, if the plant flow is 500 gpm (0.72 MGD) and a recycle rate of 75 percent is desired, the RAS flow rate should be set to 375 gpm. The RAS flowrate should be adjusted when necessitated by changes in the plant flow on weekends and holidays, and by changes in sludge characteristics.

An increase in the RAS flowrate results in a direct increase in the MLSS concentration in the aeration basins. This will also result in a decrease in the F/M ratio and an increase in the MCRT.

(5) <u>Wastewater pH</u>. The pH of the wastewater entering the aeration basin is fixed by the sodium sulfide/ferrous sulfate process. This will require a pH of 7.2 to 8.0 at the SCC outlet.

b. Sampling and Testing

Successful operation of the activated sludge system and maintaining the health of the microorganisms require continuous observation and inspection by plant operators. The primary operational checks that should be performed are described below.

(1) <u>Dissolved Oxygen</u>. At least once a shift, the dissolved oxygen (DO) concentration should be determined at the inlet and outlet of each activated sludge basin. The DO level in all areas of the aeration basins should be at least 1.0 mg/L. If testing shows a DO below that value, the blower output should be increased by opening the control valve on the discharge line. A single blower can deliver up to 100 standard cubic feet per minute (SCFM) as indicated by the air flow gage. If air in excess of 1000 SCFM is needed, a second blower should be brought on line.

After an hour, the DO level should be rechecked to determine if the level has reached the 1.0 mg/L minimum. Normally, the best range is 1.0 to 2.0 mg/L; maintaining a level higher than 2.0 mg/L does not improve treatment and can cause sludge settling problems in the secondary clarifier. The DO test should be conducted by either of the following:

- A battery operated calibrated dissolved oxygen field meter with probe is the most accurate and convenient method.

- A sample can be collected by completely filling a BOD bottle (no air at the top), sealing the bottle, and returning it to the laboratory for analysis. The lab test can be performed using a lab-type DO meter or the Winkler wet chemical method as described in the latest edition of Standard Methods for the Examination of Water and Wastewater.

The time, location, and DO level of each sample should be recorded in the operator's log.

(2) Sludge-Settling Tests. At least once every shift, a settling ability test should be run on a sample collected from each aeration tank. This test is important because it measures the ability of the solids to separate from the liquid in the final clarifier. For best results, a 1000-mL graduated cylinder should be used. The basic steps of the test are:

- Collect a sample from the middle of each aeration tank.

- Carefully mix the sample and pour it into the 1000-mL cylinder.

- Record the level of the suspended solids interface at 5-minute intervals for 30 minutes.

The first 5-minute period is one of the most important observations for this test. During this period, the operator should observe how the sludge particles stick to each other while forming the blanket and if the sludge is compacting slowly and uniformly. The 30-minute reading is also an important observation since it will be used to calculate the sludge volume index (SVI). Record test results in the operator's log.

(3) Suspended Solids. At least once a shift, the suspended solids should be measured on the same samples used for the settling ability test. Procedures for this test are described in Standard Methods for Examination of Water and Wastewater. Normally, the mixed liquor suspended solids (MLSS) in the aeration tanks should be in the range of 2000 to 4000 mg/L.

The results of the 30-minute settling ability test and the suspended solids test can be used to calculate an important operational parameter--the SVI. The formula for the SVI is:

$$\text{SVI} = \frac{\text{\% settleable solids} \times 10{,}000}{\text{MLSS (mg/L)}}$$

For example, if the percent settleable solids after 30 minutes is 30% (300 mL/1000 mL x 100) and the MLSS in the aeration tank is 2500 mg/L, the SVI can be calculated as indicated below:

$$\text{SVI} = \frac{30 \times 10{,}000}{2500} = 120.$$

Record results of the SVI test in the operator's log. The SVI is another measure of the settling ability of the sludge in the final clarifier. Normally, the SVI should be within the range of 75 to 200. Prescribed means of regulating the SVI are included in Abnormal Occurrences later in this section.

(4) Influent Sample. Every 2 hours, a sample of the influent to the aeration tanks should be taken. The collection point for this sample is a sample tap located on the inlet line, downstream of the static mixer, in the Blower House. The sample should be returned to the lab and the pH and hexavalent chromium concentration and turbidity measured. Record the results in the operator's log. It is extremely important that

the pH and hexavalent chromium concentration be maintained within the following limits:

pH	7.5 to 8.0
Cr^{+6}	0.1 mg/L or less

If the measured values for pH and chromium are not within the above limits, the operator should immediately determine the cause and take corrective action (see Abnormal Occurrences). Also, if turbidity increases above 25 NTU, a metals and cyanide analysis should be performed.

(5) Secondary Clarifier Outlet Sample. Once each shift, a sample should be collected from the outlet of each secondary clarifier. This sample should be returned to the lab and the suspended solids concentration should be determined. Record the results in the operator's log. The measured SS concentrations should be about 2 g/L.

(6) Phosphoric Acid Drum. Once each shift, the operator should check the phosphoric acid drum and replace the drum if empty.

(7) Ammonia Storage Tank. Once a day, the operator should check the gage on top of the ammonia storage tank. This gage indicates the ammonia level in terms of percent full. When the level reaches 30 percent, delivery of ammonia should be scheduled.

(8) Sludge Blanket Level. Once each shift, the operator should check the sludge level in the secondary clarifiers. The blanket should be one to three feet thick in both clarifiers, and a clear layer of water should be above the sludge blanket. A sludge blanket finder should be used for this test. The position of the blanket, in terms of feet above the tank floor, should be recorded in the operator's log.

3. Maintenance

Routine preventive maintenance as recommended by the equipment manufacturers should be completed and noted in the operator's log. Unplanned outages of major components of the biological system can cause variances in the plant's capability to discharge good-quality effluent.

This can be prevented by following proper maintenance procedures. The following procedures, in addition to those recommended by the equipment manufacturer, will help detect or avoid equipment problems.

Once a shift, check the following:

- o Blower air flow and discharge pressure
- o Secondary clarifier drive mechanism
- o Recycle sludge pumps
- o All mechanical equipment for unusual noises or malfunction.

Once a week, check or perform the following:

- o Aeration patterns in the activated sludge basins to determine if air is being distributed evenly over the entire water surface
- o Alternate equipment to provide equal operating time, then record running times in the operator's log
- o Check and clean all overflow weirs.

Clean or replace the blower filters, if necessary, during monthly inspections.

It is recommended that every three years, the activated sludge basins and secondary clarifiers be drained one at a time, flushed, and inspected. Coatings should be renewed and any structural deterioration repaired. Air diffusers should be inspected and replaced if necessary and all air and liquid lines flushed and cleaned.

Flow controls and instrumentation should be checked and calibrated at least annually or whenever unexpected or abnormal readings occur.

4. Primary Duties of the Shift Operator

Consult with the previous shift operator to determine:

- o Results of previous tests to samples
- o Operating strategies currently in use
- o Operating status of all electrical and mechanical equipment.

Check the operation of the:

- o Air blowers
- o Clarifier mechanisms
- o RAS pumps
- o RAS and WAS controllers and valves
- o Nutrient chemical feed systems.

Observe the aeration basins for the:

- o Air diffusion pattern
- o Basin mixing energy
- o Mixed liquor color, odor, viscosity, foam, etc.

Observe the secondary clarifiers for:

- o Particle carryover in the effluent
- o The sludge level

- The sludge characteristics (in the suction type clarifier where the collected sludge is visible in the sight box).

Perform the following sampling and analyses:

- Influent
  - pH
  - Hexavalent chromium
  - Turbidity
- Aeration basins mixed liquor
  - Dissolved oxygen concentration
  - MLSS concentration
  - Sludge volume index
  - Sludge settling ability
- Clarifier effluent
  - Suspended solids
  - Phosphate
  - Ammonia

Based on the observations and analyses described above, determine the need to:

- Modify the amount of aeration
- Change the RAS and/or the WAS flow rates

- o Adjust the nutrient chemical addition rates

- o Adjust the upstream processes, such as:

  - pH control

  - Hexavalent chromium removal

  - Phenol blending

  - SCC solids removal

Check the nutrient chemical supplies and reorder when appropriate.

Evaluate the planned wastewater quality and quantities that are to be discharged to the IWTP in the near future to determine if the overall operating strategy of the activated sludge system needs to be modified.

5. Startup Procedures

- o Complete a preoperation inspection of the tanks, piping, valves, blowers, aeration diffusers, collector drives and mechanisms, instrumentation, sludge recirculation pumps, and sludge wasting pumps. Refer to the manufacturer's instructions for these inspection procedures.

- o Introduce wastewater into the aeration basin or perform a clean water startup depending on the equipment manufacturer's recommendations.

- o When the aeration diffusers are covered, start feeding air to the aeration diffusers, increasing the flowrate to the design rate as the tank fills.

- o Start the final clarifier drives.

- When the clarifiers are filled, start the RAS pumps. Use a high RAS flowrate until the MLSS concentration reaches the desired level.

If no sludge is present in the system during startup, obtaining a full inventory of activated sludge may take 6 to 12 weeks, and the effluent will not be fully treated during this time. The startup period may be shortened by adding dry (dehydrated) activated sludge.

Another method for shortening the startup period is to fill the aeration basins and clarifiers with water or wastewater before plant startup. Once the tanks are filled, external flow is stopped. The captive liquid is aerated and recycled, with phenol added separately as a food source, so that the MLSS concentration is gradually increased to the desired level.

6. Shutdown Procedure

Under normal conditions, the entire biological system should never be shut down. It is possible to operate on one activated sludge tank by closing the isolation valves located on the inlet and outlet pipes of each tank. The air supply to the basin should remain on, unless the tank is being drained, to keep the sludge from becoming septic.

The total flow can also be diverted to a single final clarifier by closing the valve on the influent line. If the clarifier is to be out of service for more than a few hours, the sludge pump serving the clarifier should be used to pump as much sludge as possible out of the clarifier so that the sludge does not become septic.

For planned maintenance outages, the solids inventory in the operating units (activated sludge basins, secondary clarifiers) should be increased before shutdown. This will permit rapid startup of the system by transferring activated sludge to the basin being restarted.

Preventive maintenance or replacement on pumps, blowers, and controls should accompany any extended shutdown of an activated sludge basin or a secondary clarifier.

7. Abnormal Occurrences

a. Wastewater Quality

If increased phenol concentration in the activated sludge influent result in increased phenol concentration in the plant effluent, the microorganism population in the aeration basin should be increased to maintain a constant F/M ratio. This is accomplished by increasing the RAS flowrate. Beyond a certain level it may also be necessary to decrease the WAS flowrate.

Increased suspended solids concentration in the Solids Contact Clarifier (SCC) effluent means that the aeration basin Mixed Liquor Suspended Solids (MLSS) concentration no longer has the same relationship to the biological solids concentration. (SCC solids are not biological solids.) The measurement of Mixed Liquor Volatile Suspended Solids (MLVSS) will have a more direct correlation to the biological solids. This problem can be temporarily minimized by controlling the activated sludge system on the basis of MLVSS instead of MLSS.

High concentrations of metals or other toxic or inhibitory materials will interfere with the microorganism metabolism and reduce the efficiency of the activated sludge system. This effect can be temporarily minimized by increasing the MLVSS concentration during this period by increasing the RAS flow rate.

Low waste water temperatures slow the microorganism metabolic rate and reduce the treatment efficiency. This is minimized by increasing the MLVSS concentration by increasing the RAS flow rate.

Excessively low or high pH levels interfere with the microorganism metabolism. This is corrected by proper pH control in the equalization tank and in Mixer Basin 2.

Rapid fluctuations in wastewater quality may interfere with the biological treatment. This is corrected by proper operation of the equalization tanks.

b. Aeration Basins

Billowing white foam is an indication of an over oxidized sludge or excessively old sludge age. This is corrected by reducing the aeration or by reducing the sludge age by decreasing the RAS flow rate and/or increasing the WAS flowrate.

A scummy, dark tan foam is an indication of excessively young sludge. This is corrected by increasing the RAS flow rate and/or decreasing the WAS flow rate.

Foul odors and grey or black mixed liquor are an indication of a septic sludge. This can be caused either by insufficient aeration or excessively old sludge age. Insufficient aeration can be corrected by increasing the air flow rate by opening the blower throttling valve or by starting the second blower. The sludge age can be decreased by decreasing the RAS flow rate and/or increasing the WAS flow rate.

c. Final Clarifiers

Fine particles (pin floc) being carried over the peripheral effluent weirs results in increased loads to the chlorination and pressure filtration systems. This can be caused by excessive turbulence in the aeration basin, which breaks down the mixed liquor solids, or by an excessively old sludge age. Excessive turbulence can be corrected by reducing the air flow rate by partially closing the blower throttling valve or shutting down the second blower. Sludge age can be decreased by decreasing the RAS flow rate and/or increasing the WAS flowrate.

Sludge clumps floating at the surface of clarifier and over the weirs are a similar problem. This is caused by an anaerobic sludge which produces gas. This can be corrected by increasing the dissolved oxygen (DO) concentration in the MLSS or by decreasing the length of time that the sludge is held in the clarifier. The DO can be increased by increasing the air flow rate by opening the blower throttling valve or starting the second blower. The sludge holding time in the clarifier can be decreased by increasing the RAS flow rate and/or increasing the WAS flowrate.

Filimentous microorganisms can develop in the sludge. Microscopic examination can be used to determine if filimentous organisms exist. They interfere with the normal thickening of the sludge and can cause the normal inventory of sludge to back up to the water surface where it overflows into the clarifier effluent. A number of techniques can be tried to eliminate the filamentous microorganisms:

- Increase the sludge age by increasing the RAS flow rate and/or decreasing the WAS flowrate.

- Increase the feed rate of the nitrogen and phosphorous nutrients.

- Treat the sludge with chemicals such as chlorine, ozone, or hydrogen peroxide. It is extremely important that these chemicals not be fed in quantities great enough to disrupt the biological treatment process. Initial testing of the chemicals in jar tests is a quick and safe means for determining an appropriate chemical and dosage rate. Any chemical treatment program should be carefully planned, controlled, and evaluated.

K. CHLORINE CONTACT TANK

The purpose of the chlorine contact tank is to mix chlorine with the wastewater and provide contact time for the chlorine to chemically oxidize any remaining organic compounds in the water.

1. Equipment

The major equipment connected with the chlorine contact tank are the chlorine feed system and the contact tank. Gas chlorine is fed from cylinders in the Gas Chemical Building and is carried in a water solution to the contact tank, which is a concrete tank 45 feet long x 22 feet wide x 6 feet deep. Baffles in the tank provide a serpentine flow path to minimize short circuiting.

Two vertical lift pumps are located in the effluent end of the chlorine contact tank. These pumps are a part of the pressure filter system and are described under that section of this manual.

2. Normal Operation

a. Operating Strategy

The chlorine dosage rate is adjusted to provide complete oxidation of organic compounds in the final clarifier effluent.

b. Sampling and Testing

No sampling or testing is required of the waste water in the chlorine contact tank. Instead, COD is measured in the plant effluent.

3. Maintenance

Maintenance of the gas chlorine feed equipment is to be performed according to the manufacturer's instructions. Every 3 years, the contact tank should be drained, inspected, cleaned, and repaired as necessary.

4. Primary Duties of the Shift Operator

- o Consult with previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use and (c) operating status of all electrical and mechanical equipment.

- Check the operation of the gas chlorination system.

- Weigh the chlorine cylinder and replace it with a full cylinder when needed.

- Check the number of full chlorine cylinders and reorder when appropriate.

- Measure the COD of the plant effluent.

- Based on the plant flowrate and effluent COD, determine the need to adjust the chlorine dosage rate.

5. Startup Procedure

The gas chlorine feed equipment should be started up in accordance with the manufacturer's instructions.

6. Shutdown Procedures

The gas chlorine feed equipment should be shut down in accordance with the manufacturer's instructions.

7. Abnormal Occurrences

Mechanical failures of the gas chlorine feed equipment should be repaired in accordance with the manufacturer's instructions.

A high COD concentration in plant effluent may indicate an inadequate chlorine dosage rate, which should be corrected by increasing the chlorine dosage rate.

L. PRESSURE FILTERS

The purpose of the pressure filters is to remove suspended solids from the wastewater following biological treatment. The solids consist primarily of solids that would not settle in the secondary clarifier.

1. Equipment

The pressure filter system consists of two single-cell horizontal filters, 8 feet in diameter and 8 feet long, and a backwash control panel. Auxiliary equipment for the filter system includes two vertical turbine lift pumps and a polymer feed system.

2. Normal Operation

a. Operating Strategy

Wastewater passes through three layers of filter media, which remove suspended solids. From top to bottom, the layers are: 16.5 inches of anthracite coal, 9 inches of sand, and 4.5 inches of garnet. The normal flow pattern is for wastewater to enter the top of the filter, pass through the layers of filter media, and out the bottom through an underdrain system. As the filter removes solids from the water, it becomes blocked and more pressure is required to force the water through the filter. A device on the filter measures this pressure increase and sounds a "high head loss" alarm when the pressure reaches 20 psi.

A "high head loss" alarm indicates that the filter must be cleaned by backwashing, or forcing water through the filter in the direction opposite normal flow and at a higher flowrate. During the backwash, solids are flushed out of the filter and piped to the equalization basins at the head of the treatment plant. After the operator manually starts the backwash, the filter control system automatically backwashes the filters one at a time and returns them to service.

If necessary to increase filter efficiency, polymer solution can be added to the wastewater entering the filters to flocculate the small suspended particles and make them larger and easier to filter.

Two 750-gpm vertical turbine lift pumps transfer wastewater from the chlorine contact tank to the pressure filters. Under normal conditions, one pump can handle the entire plant flow. The pumps are controlled by pushbuttons and disconnect switches mounted on the wall adjacent to the pumps.

A level control circuit determines the level in the chlorine contact chamber by adjusting the influent valves on the pressure filters. The level controller, located on the main control panel, has a scale that reads from 0 to 100. This scale corresponds to depths of 0 to 10 feet in the chlorine contact chamber. During normal operation, set the controller in the AUTO position using the switch at the bottom of the unit. Use the thumbwheel to adjust the set point (the orange bar) to 70 (7 feet) on the scale. The controller should regulate the actual depth, indicated by the red bar, to coincide with the set point.

The level can also be controlled manually by placing the Flow Indicator Control (FIC) unit in the MAN position. In this mode, the bottom thumbwheel is used to vary the flow control valves on the filters and thus vary the water level in the contact chamber. When operating in this mode, the operator must continuously monitor the actual level in the wet well (the red bar on the controller) and adjust the controller accordingly. If the level gets too high, it will cause the chlorine contact chamber to overflow. If the level gets too low, it could damage the lift pumps by causing them to cavitate or run dry.

Flow from the lift pumps is split equally between the pressure filters. Normal flow rate is 290 to 520 gpm to each filter. Filter operation is controlled and monitored using the local control panel in the filter building. This panel is equipped with flowrate indicators for the wastewater passing through each filter, indicators for the backwash flowrate, and control switches and operating status lights for each filter.

After a period of use, the filters will become plugged with solids and must be backwashed. In the backwash process, one filter is taken out of service and water from the treated effluent storage tank is pumped through a surface wash device at 120 gpm, which breaks up the layer of solids that may have formed on the filter surface. The duration of the surface wash can be varied by adjusting the timer on the control panel. The normal length of time of the surface wash is 4 minutes. Following surface wash, water from the treated effluent storage tank is pumped into the bottom of the filter, flushing the solids out through the top of the filter. The backwash water is diverted to the equalization tanks at the head of the treatment plant. The backwash time can be varied by adjusting the timer on the control panel. Normal backwash time is 10 minutes. The backwash flow rate can also be varied using the backwash flow controller on the filter panel.

High pressure alarms for each filter are located on the main control panel. If the alarm is activated, the operator should start backwash of the filters as soon as possible. To backwash the filters, the operator presses the pushbutton labeled BACKWASH on the filter control panel in the filter building. With both filter selector switches in the AUTO position, each filter will be automatically backwashed and returned to service, one after the other. The backwash pump located in the treated effluent pump station must be in the AUTO position for automatic filter backwash.

Each filter has a control switch on the filter panel labeled AUTO-SERVICE-STANDBY. This switch controls the filter as follows:

AUTO	Filters backwash automatically, one at a time, after the BACKWASH button is pushed.
SERVICE	Filters are on-line, but will not backwash.
STANDBY	Filter is off-line with all valves closed.

The filter panel also has status lights for each filter labeled BACKWASH, SERVICE, STANDBY, and HIGH P. A second set of status lights is located on the main control panel in the Chemical Building.

A polymer feed system, designed to add dry polymer to the influent of the pressure filters, is located in the north end of the Filter Building. The system, which can be operated either in a manual or semiautomatic mode, contains four major components: a dry polymer feeder, a 75-gallon mix tank, a 150-gallon storage tank, and two 125-gph polymer metering pumps. All of the above components, including a control panel, are mounted on a common skid. The system is designed to mix an exact quantity (typically, 25% by weight) of dry polymer with water to form a polymer feed solution, which is transferred to the storage tank. Polymer metering pumps add polymer solution to the wastewater just before it enters the pressure filters.

The procedure for mixing a new batch of polymer is as follows:

- o Make sure the feed system hopper contains enough dry polymer.
- o Turn the four three-way switches, located across the top of the polymer system control panel, to the OFF position.
- o Going from left to right, turn these same four switches to the AUTO position. The system automatically mixes a new batch of polymer and transfers this solution to the storage tank as needed.

a. Sampling and Testing

Filter influent and effluent samples should be taken and laboratory-tested for turbidity as discussed earlier.

3. Maintenance

- o Flow control circuits should be recalibrated at least annually.

- The tank internals should be checked annually. During this inspection, the surface wash device should be tested for proper operation. If necessary, additional media should be added to maintain the 2-inch distance between the centerline of the surface wash arm and the top of the media. The cause of any excessive media disturbance should be investigated and corrected.

4. Primary Duties of the Shift Operator

- Consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- Check the operation of the pumps and controls, which are located in the chlorine contact chamber, the pressure filters and controls and the polymer feed system.

- Check the level in the polymer feed tank every 2 hours and make up a new batch when needed.

- Check the amount of dry polymer powder in the feed system hopper and add more when appropriate.

- Check the amount of dry polymer powder in stock and reorder when appropriate.

- Check the filter HIGH PRESSURE status lights and backwash when appropriate.

- Measure the turbidity in the filter influent and effluent.

- During the work shift, record in the operator's log the time of automatic backwashes and the duration of filter use between backwashes.

5. Startup Procedure

- Start up the pressure filter system according to the manufacturer's instructions.

- Verify the integrity of all electrical, pneumatic, and hydraulic connections.

- Calibrate any instruments supplied according to the manufacturers' instructions.

- Dry-run test all valves supplied.

  - Do not fill filter tank(s). Close isolating valves if required.

  - Turn on electrical power, and connect air and hydraulic pressure source if required.

  - Operate each butterfly valve, using manual controls, and verify that each fully opens and closes.

  - Operate each diaphragm valve and verify that pressure is applied to the diaphragm. If the pressure source is not operational, verify that the controlling electric solenoid valve operates.

  - Manually initiate the backwash cycle, observe the automatic sequencing of valves, and verify that the valves operate in sequence through the cycle. Also, verify that the valves operate in the sequence shown on the drawings. (Test time can be minimized by setting all timers to the minimum time.) Make any corrections or adjustments necessary.

- Fill each tank carefully, at no more than 25 percent of the design service flow rate, because excessive flow rate may upset the filter bed. If possible, fill from the top to the bottom.

If plant piping does not permit, the tank may be filled from the bottom up. Do not pressurize any surface wash system. Stop filling when the water level covers the filter media.

- If possible, briefly backwash the tank at the design backwash rate and observe the bed through the open manway. Look for uniform fluidization. Localized jetting or disturbance may indicate a broken lateral or other underdrain problem which must be corrected before proceeding. Call the manufacturer if abnormalities exist.

- Close manways. Take care that the gaskets are properly sealed.

- Open valves below any of the air relief valves.

- Continue filling until the air flow stops at all air vents.

- If the backwash flow rate is field-adjustable, set it in accordance with the following table.

Temperature (°F)	Backwash Flow (gpm)
90	2350
80	2130
70	1940
60	1730
50	1550
40	1400

- Manually initiate a backwash cycle and run until the backwash water becomes clear.

6. Shutdown Procedure

- For short periods of several days, the filters can be placed on STANDBY by means of the control panel selector switch. Keep power to the control panel ON.

- For periods of a week or more, backwash the filters, then place the filters on STANDBY and close the manual isolation valves located on the inlet and outlet of each filter. Turn the power to the control panel OFF and place the backwash pump selector switch and circuit breaker in the OFF position. Open the drain valve only long enough to relieve pressure on the filter vessels.

- If the filters are taken out of service during freezing weather, consideration should be given to draining the tanks to the top of the filter media. Completely draining the filter should be avoided since it introduces air pockets into the bed.

- If power to the filters is lost, the filter will remain in service as long as adequate air pressure is available and the level control system is operating. If a filter is in backwash when power failure occurs, the backwash control valve will close and the backwash duration timer will stop for the duration of the outage. The backwash cycle will continue to its normal completion when power is restored.

7. Abnormal Conditions

Flow through the pressure filters will normally be approximately equal to the flow entering the chlorine contact chamber. On the filter control panel, each filter has a flow indicator controller (FIC) with a switch for manual (MAN) and automatic (AUTO). If the switch is in the AUTO position, flow is controlled by the level in the chlorine contact chamber. In the MAN position, the flow through each filter can be manually set using the knob on the bottom of the controller. If the filters are operated with the switch in the MAN position, the operator must watch the level in the chlorine contact chamber and adjust the filter flow as necessary to maintain the required level.

Turbidity of the filtered effluent should be evaluated daily to determine if the filters are operating properly. The filters should normally reduce the turbidity of the wastewater by 70 to 90 percent. For example, if the turbidity of the wastewater entering the filters is 50 units, the turbidity of the water leaving the filter should be in the range of 5.0 to 15 units. If the turbidity of the filtered water is consistently higher than expected, the operator should investigate the reasons for poor performance:

- Increase or decrease the polymer feed rate using the adjustment knob on the top of the metering pump. This knob is calibrated from 0 to 100 percent of rated capacity (125 gph). The feed rate should be increased or decreased in units of 10% and the effect on filtration evaluated after each adjustment.

- Check the differential pressure at which the high pressure alarm is activated. The differential pressure that triggers a backwash should be 20 psi. If necessary, adjust the high pressure set point to alarm at 20 psi.

The time between backwashes should be evaluated daily to determine the duration of filter use. If the duration of filter use decreases significantly, the operator should:

- Backwash the filters and check for proper operation during the surface wash and backwash cycles. The flow rate during the surface wash should be 120 gpm. The flow rate during the backwash should be adjusted according to the table presented earlier in this section (paragraph 5, under Startup Procedure). If the backwash flow rate adjustment does not improve filter performance, the length of the surface wash and backwash cycles should be increased using the timers located on the filter control panel.

- Increase or decrease the polymer feed rate and evaluate the effect on filter performance. (Short filter runs can be caused by improper, or lack of, polymer feed.)

- Check the SS level of the wastewater entering the filters because high levels will cause short filter runs. The normal SS concentration in the filter influent should be 20 to 40 mg/L. Upsets in the biological system can cause sludge to overflow the final clarifiers and cause rapid filter plugging.

The operator should be alert to the loss of filter media during backwashing. This loss is most often caused by an excessive backwash flowrate, which should be checked and reduced if necessary.

M. RECLAIMED WATER STORAGE TANK

The purpose of the reclaimed water storage tank is to provide a place to store a significant volume of treated wastewater. This allows some or all of the reclaimed water to be reused on the AFB.

1. Equipment

The reclaimed water storage tank includes no significant equipment other than the tank itself, connecting piping, and valves. The aboveground painted steel tank is 50 feet in diameter, 33 feet high at the side wall, and holds approximately 1 million gallons. The pressure for filling the tank is developed by the pumps at the effluent end of the chlorine contact chamber and transmitted through the pressure filters.

2. Normal Operation

a. Operating Strategy

The only operating strategy is the decision to send the treated water from the IWTP to the reclaimed water storage tank or into Soldier Creek. This decision may be based on factors such as the economics associated with reducing the use of fresh water or the quality of the treated wastewater.

b. Sampling and Analysis

No sampling or testing is required for the operation of the reclaimed water storage tank other than those associated with other treatment processes and/or those required by regulatory agencies.

3. Maintenance

Once every 3 years, the tank should be drained and cleaned. Any accumulated solids should be removed. The tank, connections, and fittings should be inspected for physical damage, corrosion, and paint coating integrity. Any necessary repairs or repainting should be performed at this time.

4. Primary Duties of the Shift Operator

The shift operator should consult with the previous shift operator to determine if the treated water is being discharged into the storage tank or Soldier Creek and any information relevant to the status of the tank. The operator should also check the water level in the storage tank.

5. Startup Procedures

Startup of the reclaimed water storage tank requires setting the valves to direct the treated water to the storage tank or into Soldier Creek.

6. Shutdown procedure

Short-term shutdown of the reclaimed water storage tank requires setting the influent and effluent valves. Long-term shutdown requires setting the influent and effluent valves, and draining and cleaning out the tank.

7. Abnormal Occurrences

Difficulties in moving water into or out of the reclaimed water storage tank may be due to incorrectly set valves, malfunctioning valves, or obstructions in the piping.

N. SLUDGE THICKENER

The purpose of the sludge thickener is to concentrate the waste sludges from the Solids Contact Clarifier, Softener Basins, and Activated Sludge Secondary Clarifiers. This decreases the quantity of sludge sent to the sludge dewatering vacuum filter and improves the performance of the vacuum filter.

1. Equipment

The sludge thickener concrete tank is 30 feet in diameter, 9 feet deep at the side wall, and has a 1-5/8-inch to 12-inch floor slope. The sludge enters the side wall of the thickener tank through an 8-inch horizontal pipe which discharges inside the influent well. A full-diameter bridge supports two rake arms, an electric motor, and a reduction gear box. On the two rake arms are plows to move the sludge to the central sludge removal hopper, and vertical pickets to open passages in the sludge bed and allow water to escape from the thickening sludge bed. The mechanism is rotated by an electric motor driving through the reduction gears mounted on the bridge. The bridge provides personnel access and electrical service connection from the tank wall to the central drive.

2. Normal Operation

a. Operating Strategy

Sludge is transferred from the various clarifiers into the thickener on an intermittent basis as required for the proper operation of those clarifiers. However, whenever possible, sludge wasting from the clarifiers should be accomplished in short, frequent transfers.

Infrequent transfers of long duration can result in hydraulic overloading of the thickener with excessive solids carryover in the effluent.

The sludge level should be allowed to increase in the thickener as long as the mechanical drive is not overloaded and the sludge is not carried over into the effluent. Deeper sludge levels produce more concentrated sludge for transfer to the vacuum filter.

Sludge should be transferred from the thickener to the vacuum filter in large batches to minimize the frequency of operation of the vacuum filter, but not in such a large batch that excessively thin sludge is transferred.

b. Sampling and Testing

Once a day, a core sample-type tube should be used to determine the sludge level in the thickener.

3. Maintenance

Maintenance of the thickener drive and mechanism should be carried out in accordance with the manufacturer's instructions. Once every three years, the thickener tank should be pumped out for inspection, cleaning, and repairs as required. All pipes and valves should be carefully cleaned and inspected.

4. Primary Duties of the Shift Operator

- Consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- Check the operation of the thickener mechanism and the thickener drive torque.

- Check the sludge level in the thickener.

- Transfer sludge to the sludge filter holding tank when indicated by the drive torque or the sludge level. The date, time, duration, and starting and ending sludge levels should be recorded in the operator's log for all sludge transfer.

5. Startup Procedure

- Follow the preservice checkout of the thickener mechanism as described in the manufacturer's instructions.

- Start the thickener drive and start sludge transfer into the thickener.

6. Shutdown Procedure

- Transfer sludge from the thickener to the vacuum filter.

- Flush out the sludge transfer pipes.

- Pump the water out of the thickener and stop the thickener drive.

7. Abnormal Occurrences

Excessive solids carryover in the effluent can be caused by excessively long durations of sludge transfers into the thickener, which results in a hydraulic overload. This situation can be corrected by transferring the sludge in shorter, more frequent discharges. Another cause of excessive solids carryover is an excessively high sludge transfer flowrate into the thickener, which can be corrected by decreasing the sludge transfer flowrate.

This condition can also be caused by a sludge blanket that has been allowed to become too deep. Transferring sludge from the thickener to the vacuum filter corrects the problem.

Another abnormal occurrence is excessively thin sludge being transferred from the thickener to the vacuum filter. This can be caused by allowing the sludge level to get too low, and can be corrected by allowing more sludge to accumulate before starting the transfer or by terminating the transfer sooner.

Another abnormal occurrence is overloading of the thickener drive. This can be caused by an excessively thick sludge blanket, and can be corrected by decreasing the sludge level or decreasing the polymer dosage rate in the clarifier. Overloading can also be caused by an obstruction in the tank, such as a dropped tool, a bent-scum trough, etc. In this case, the tank must be drained and the obstruction removed.

O SLUDGE DEWATERING VACUUM FILTER

The purpose of the vacuum filter is to dewater the thickened sludge to form a sludge cake that can be hauled to a disposal site in open trucks.

1. Equipment

The sludge holding tank is a steel tank 12 feet in diameter and 18 feet high. The dewatering filter system also includes (a) a flocculator mixer, (b) two positive displacement transfer pumps, (c) chemical feed system (currently not in use), (d) vacuum pump system, (e) filter tank with agitator, (f) vacuum belt filter with drive, filter belt, filter cloth, and belt wash, (g) filtrate pump, (h) dewatered sludge conveyor belt, and (i) control panel.

2. Normal Operation

a. Operating Strategy

The complete volume of sludge in the holding tank should be filtered daily. The sludge dewatering process and equipment operation should be carefully monitored so as to produce a dry sludge cake suitable for removal in an open truck.

b. Sampling and Testing

Daily samples of the sludge cake should be collected and tested to determine the total solids content in accordance with Procedure 209-F of <u>Standard Methods for the Examination of Water and Wastewater, 16th Edition</u>. The test results should be recorded in the operator's log.

3. Maintenance

The sludge dewatering vacuum filter is a complex system. A comprehensive maintenance program should be followed to ensure the proper operation and to prevent equipment failures. The operator should read the manufacturer's manuals on the accessory equipment and be thoroughly familiar with the procedures for inspection, lubrication, adjustments, and detailed maintenance information.

4. Primary Duties of the Shift Operator

- Consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) operating status of all electrical and mechanical equipment.

- Check the operation of the sludge holding tank mixer.

- Check the sludge level in the sludge holding tank.

- Determine the need for sludge filtration during the shift.

5. Startup Procedure

NOTE

Never adjust the speed of a variable speed drive unless the motor is running.

- Check each system component for proper rotation and operation, and complete any lubrication and adjustments recommended by the manufacturer.

- Start the filter drive and check the drum for proper direction of rotation.

- Start the cloth and roll wash water. Inspect the wash nozzles to be sure they are free and positioned properly.

- Check the filter cloth for alignment and tension, referring to the manufacturer's instructions.

- Close the valve in the top vacuum line leading from the filter valve to the receiver. This valve should remain closed during the next test since it controls the vacuum in the drying zone of the filter, and in the absence of cake formation, this zone is exposed to atmosphere.

- Close the tank drain valve and fill the tank to the overflow or operating level with water and maintain it at this level.

- Turn on the seal water to the filtrate pump and vacuum pump (cooling water for dry type pumps). Start the pumps.

- Rotate the drum for two or three revolutions. Then stop the vacuum and filtrate pumps, in that order, and drain the tank. Stop the filter drive.

- Shut off the seal water and the cloth wash header. Inspect the filter before starting normal operation. Make any needed adjustments.

- Remove an access panel to the drum and inspect the inside of the drum, including the vacuum piping, for any signs of leakage.

- If the filter will be idle for more than 2 hours, release the tension on the filter belt by turning the takeup roll cranks an equal number of turns. This will prevent stretching or over-stressing the cloth as it dries. Note the number of turns of the adjusting cranks or number counters so that the takeup roll can be returned to its original position at startup. Any serious difficulty encountered should be referred to the manufacturer.

- Start the chemical feeder pump(s), if being used. Then start the sludge pump and adjust it for proper capacity.

- As the sludge approaches the 20 percent submergence level (20% of the drum circumference is submerged, start the filtration pump.

- When the sludge level reaches 20 percent submergence, start the vacuum pump and, if it is the wet type, adjust the seal water to obtain the highest possible vacuum. Start the filter drive and set the speed at approximately 3 rpm until the proper operating speed can be determined.

- When the cake reaches the 10:00 o'clock position on the drum, gradually open the drying valve to the receiver. This will help prevent the cake from sloughing off the drum. Continue opening the valve until it is fully open (but maintain at least 5 to 7 inches of mercury vacuum throughout the drying cycle).

- Start the conveyor, if supplied.

- Adjust the sludge feed as necessary to maintain the sludge at the optimum operating level.

- By the time the drum has made one or two complete revolutions, the cake should be breaking off from the belt in pieces or sheets the full length of the discharge roll. If it is not, refer to the manufacturer's instructions.

- o Adjust the filter speed to produce a dry cake approximately 1/8 to 3/8 inches thick for digested sludge and 1/4 to 1/2 inches thick for raw sludge. These figures apply as a rule, but since the results obtained depend on the sludge characteristics, the thickness will vary, depending on a number of variables which are part of any sludge process.

  Watch the belt for signs of wrinkling, biasing, mooning, and excessive slack, and if necessary, adjust the belt as recommended in the manufacturer's instructions.

- o When the cake is completely discharging from the belt, it may be possible to reduce the takeup roll and inside belt wash water flowrate. But watch carefully for cloth binding, which is obvious when flat spots appear on the cake.

- o Periodically check that the filter belt wash pipe holes are not plugged as indicated by an uneven spray pattern.

6. Shutdown Procedure

To shut down the filter:

- o Stop the sludge pump and chemical feeder pumps.

- o Stop the chemical mixer(s) and flocculator mixer.

- o Allow the filter to operate until the sludge level in the tank drops to a point that air is drawn through the drum piping, then shut off the vacuum pump and its seal or cooling water.

- When enough clean cloth has run over the tension roller, shut the wash header off (leave the other wash headers on while the belt is turning).

- Stop the filtrate pump and shut off its seal water when the filter tank is empty.

- Drain the tank and shut off the agitator.

- Run the filter for at least five complete revolutions of the belt or until the belt is thoroughly clean. (Extended belt washing is beneficial.)

- Shut off the belt wash header and stop the filter drive.

- Flush the wash trough through the plug opening, and flush the tank if the filter is to be shut down longer than eight hours. Wash down the filter and the flocculator mixer tank and weirs.

NOTE

Thoroughly wash down the filter belt and clean up the filter station to ensure trouble-free operation and reduce maintenance.

- Release the tension on the filter belt by turning the cranks on the takeup roll an equal number of turns. This will prevent stretching or over stressing of the cloth when it dries. Record the number of turns of the adjusting cranks so that the takeup roll can be returned to its original position at the next startup.

- Release the spring-loaded guide rollers from the edge track.

- Inspect and lubricate the filter and accessory equipment, and make any needed repairs according to the manufacturer's instructions.

7. Abnormal Occurrences

The following items affect the discharge of sludge cake. Each should be thoroughly investigated before making any adjustments. If these adjustments fail to produce satisfactory results, consult the manufacturer.

a. Dryness of the Cake

The cake will not discharge from the belt if too wet, since it adheres to the cloth. This problem often occurs if the cycle time (filter speed) is too fast for the cake to dry properly. When the cake is not sufficiently dry, it usually has a glossy surface. Before changing the filter speed, however, check the vacuum gages, referred to below.

b. Vacuum Level

The vacuum level for optimum operation should be between 17 and 22 inches of mercury. When the vacuum is not satisfactory, check (a) the vacuum pump for proper operation and adjustment, (b) improper submergence level in the tank, which allows short-circuiting of atmospheric air into the vacuum system, (c) leakage in the vacuum piping, or (d) the check valve on the filtrate pump not operating correctly, allowing air to be pulled through the pump.

c. Sludge Mixing

The feed should be homogenous and evenly distributed, otherwise the cake may not discharge from some areas of the drum, particularly at the ends. Check for uniform distribution of feed along the filter tank and, if necessary, use baffles to achieve better mixing. However, beware of excessive mixing and retention time of the sludge, for it may break up the floc. Check the discharge from the flocculator mixer to determine if the mixer is operating too fast. Also check the sludge in the tank for the size of the floc. If the floc size is less than the initial size, either reduce the speed of the tank agitator or stop it, then run it intermittently, as necessary.

d. Sludge Condition

Sludge retained too long before filtering will go septic. When this occurs, the cake will not dry adequately and, in many cases, the chemicals cannot yield a proper kind of floc to effect discharge. This should be investigated, particularly if the sludge has been retained for any length of time.

e. Submergence Level

The filter valve was set up at the factory for a specific submergence level.If the sludge level is not maintained above the design submergence, air will be pulled through the drum piping, causing a partial or complete loss of vacuum. Thus, the cake will fail to form and discharge properly. Check the operating submergence. Refer to the manufacturer's instructions.

f. Cloth Binding

Cloth binding is caused by fine particles plugging the interstices of the filter cloth; thus, no cake will form. This is seldom a problem and occurs only if the cloth wash water nozzles are plugging or if the water pressure is not adequate. Refer to the manufacturer's instructions.

g. Cake Thickness

The equipment and process should be adjusted so that the dry cake formed from digested sludge is about 1/8 to 3/8 inch thick. Generally, if this thickness is exceeded, the cake will not dry properly and will not discharge completely from the belt. Refer to Startup Procedure earlier in this section.

SECTION IV

SUMMARY OF THE SHIFT OPERATOR'S PRIMARY DUTIES

This section summarizes the duties of the shift operator. More detailed descriptions and explanations are given in the preceding sections.

The oncoming shift operator should first consult with the previous shift operator to determine (a) results of previous tests and samples, (b) operating strategies currently in use, and (c) the operating status of all electrical and mechanical equipment. During each shift, the operator is also responsible for performing all the inspections, adjustments, sampling, and testing described in this manual and in the equipment manufacturer's instructions.

A. Blending Tanks

- Contact the aircraft maintenance scheduling personnel to determine the current planned discharge of phenol-containing wastes.

- Determine the liquid level in the blending tanks.

- Evaluate the need to revise the current operating strategy based on the current liquid levels and planned phenol waste discharge plans.

- Monitor or revise the blending tank transfer rate to be consistent with the operating strategy.

B. Oil Separators

- Check the operation of the separator mechanism.

- Check the separator drive torque.

- Look for visual evidence of excessive oil buildup on the surface of the separator or oil being carried out with the separator effluent.

C. Equalization Tanks

- Check the operation of the aerators, caustic feed system, and the flow rate control valve.

- Contact the aircraft maintenance scheduling personnel to determine the planned total hydraulic discharges to the IWTP.

- Evaluate the need to adjust the flowrate from the equalization tank.

- Check the level of the caustic solution in the feed tank and switch tanks when appropriate.

- Check the number of full caustic feed tanks and reorder when appropriate.

- Monitor the level in the equalization tanks and determine when to switch equalization tanks.

D. Mixer Basin 1

- During freezing weather, check the operation of the sodium sulfide storage tank and piping heaters.

- Check the operation of the mixer and the sodium sulfide feed system.
- Review the plant flowrate, hexavalent chromium concentration, and planned sodium sulfide dosage rate.

- Verify that the correct sodium sulfide dosage rate is being used.

- Check the level in the sodium sulfide storage tank and reorder when appropriate.

E. Mixer Basin 2

- During freezing weather, check the operation of the ferrous sulfate and sulfuric acid storage tank and piping heaters.

- Check the operation of the mixer, the ferrous sulfate and sulfuric acid feed systems, and the pH control system.

- Review the plant flow rate, hexavalent chromium concentration, sodium sulfide dosage rate, and the planned ferrous sulfate dosage rate.

- Verify that the correct ferrous sulfate dosage rate is being used.

- Check the level in the ferrous sulfate and sulfuric acid storage tanks and reorder when appropriate.

- Every hour, measure and record the pH in Mixer Basin 2.

- Clean and calibrate the pH probe daily.

F. Mixer Basin 3

- During freezing weather, check the operation of the cationic polymer storage tank and piping heaters.

- Check the operation of the mixer, polymer feed system, and the streaming current detector control system.

- Review the plant flowrate, the ferrous sulfate dosage rate, and the planned polymer dosage rate.

- Verify that the correct polymer dosage rate is being used.

- o Check the operation of the automatic controller for preparing the dilute polymer feed solution.

- o Check the level in the ferrous sulfate and sulfuric acid storage tanks and reorder when appropriate.

G. Solids Contact Clarifier

- o During freezing weather, check the operation of piping heaters and the equipment in the chemical building.

- o Check the operation of:

  - The clarifier mechanism

  - The internal sludge recirculation mixer

  - The external sludge recirculation pumps and controls

  - The anionic polymer feed system

  - The continuous flow analyzer (CFA)

  - The continuous flow turbidimeter.

- o Review the plant flowrate and determine that the anionic polymer dosage rate is correct.

- o Check the level in the anionic polymer feed tank and prepare a new batch when required.

- o Check the inventory of powdered anionic polymer and reorder when required.

- o Measure the sludge level in the clarifier.

- o Measure the solids concentration, by volume, in the mixing well of the SCC.

H. Primary Lift Station

- o Check the level controller to make sure the set level in the wet well is being maintained.

- o Check the operation of the pumps and control valve.

I. Softener Basins

If the softener basins are not being used for softening the wastewater, but only as additional clarifiers, check the operation of the clarifier mechanism and the sludge draw-off valve and control.

J. Activated Sludge System

- o Check the operation of the :

  - Air blowers

  - Clarifier mechanisms

  - RAS pumps

  - RAS and WAS controllers and valves

  - Nutrient chemical feed systems.

- o Observe the aeration basins for the:

  - Air diffusion pattern

  - Basin mixing energy

  - Mixed liquor color, odor, viscosity, foam, etc.

- Observe the secondary clarifiers for:

  - Particle carryover in the effluent

  - The sludge level

  - The sludge characteristics (in the suction type clarifier where the collected sludge is visible in the sight box).

- Perform the following sampling and analyses:

  - Influent.

    pH

    Hexavalent chromium

    Turbidity.

  - Aeration basins mixed liquor.

    Dissolved oxygen concentration

    MLSS concentration

    Sludge Volume Index

    Sludge settling ability.

  - Clarifier effluent.

    Suspended Solids

    Phosphate

    Ammonia.

- o Based on the observations and analyses described above, determine the need to:

  - Modify the amount of aeration

  - Change the RAS and/or the WAS flowrates

  - Adjust the nutrient chemical addition rates

  - Adjust the upstream processes, such as:

    PH control

    Hexavalent chromium removal

    Phenol blending

    SCC solids removal.

- o Check the nutrient chemical supplies and reorder when appropriate.

- o Evaluate the planned wastewater quality and quantities that are to be discharged to the IWTP in the near future to determine if the overall operating strategy of the activated sludge system needs to be modified.

K. Chlorine Contact Chamber

- o Check the operation of the gas chlorination system.

- o Weigh the chlorine cylinder and replace it with a full cylinder when appropriate.

- o Check the number of full chlorine cylinders on hand and reorder when appropriate.

- o Measure the COD of the plant effluent.

- Based on the plant flow rate and effluent COD determine the need to adjust the chlorine dosage rate.

L. Pressure Filters

- Check the operation of the pumps and controls (located in the chlorine contact chamber), the pressure filters and controls, and the polymer feed system.

- Check the level in the polymer feed tank every 2 hours and make up a new batch when needed.

- Check the amount of dry polymer powder in the feed system hopper and add more when appropriate.

- Check the amount of dry polymer powder in stock and reorder when appropriate.

- Check the filter High Pressure status lights and backwash when appropriate.

- Measure the turbidity in the filter influent and effluent.

M. Reclaimed Water Storage Tank

- Check the water level in the tank.

N. Gravity Sludge Thickener

- Check the operation of the thickener mechanism.

- Check the thickener drive torque.

- Check the sludge level in the thickener.

- Transfer sludge to the sludge filter holding tank when indicated by the drive torque or the sludge level. The date, time, duration, and starting and ending sludge levels should be recorded in the operator's log for all sludge transfers.

O. Vacuum Sludge Filter

- o Check the operation of the sludge holding tank mixer.
- o Check the sludge level in the holding tank.
- o Determine the need for sludge filtration during the shift.
- o Filter sludge if required.
- o Observe the operation of the filter and the formation of the sludge cake. Adjust the chemical feed, filter drum speed, and vacuum level as required to optimize the filter operation.
- o Enter the duration of filtration, chemical feed rate, drum speed, vacuum level, process adjustments, and operating problems in the operator's log.

SECTION V

TROUBLESHOOTING GUIDE

The following guide is designed to assist the operator in identifying and correcting process control problems. It is organized by each unit process in the wastewater flowstream. Potential abnormal events or process control parameters are listed as "Observation" and brief statements of "Cause" and "Corrective Action" are noted.

Because many of the chemical reactions and physical processes involved in the treatment plant are interdependent, no single corrective action may solve a given problem. This guide will serve, however, as a valuable aid in plant operation and understanding these interdependencies. It should be used as a first step in correcting process control problems.

Unit Operation	Observation	Cause	Corrective Action
		18.1	
Blending Tanks Store and Blend High Strength Phenols	Overfill	Increased influent rate Effluent rate too low Storm water	1. Increased feed to oil separator[a] 2. Reduce inflow rate 3. Pump to tank trucks 4. Repair timer or pump to oil separator
	Underfill	Decreased influent rate Effluent rate too high Broken piping and/or tank	1. Reduce feed to oil separator[b] 2. Repair timer 3. Repair piping and/or tanks
		18.2	
Oil Separator Separate Floatable and Settleable Oily Wastes	Excess oil in weir overflow	Influent contains excess oil	1. Separate oil at source 2. Reduce influent flow
		Skimmer inoperative	1. Repair skimmer
		Weir rates too high or uneven	1. Clean and/or level weir 2. Reduce influent flow rate
	Torque alarms ON in rake arm drive mechanism	Excess solids in influent	1. Separate solids at source
		Broken mechanism	1. Drain, inspect and repair 2. Check mechanical drive
		Mechanism scraping tank	1. Relevel mechanism

a. Monitor phenol load changes for possible increase in return activated sludge recycle rates.

b. Monitor phenol loads to assure adequate food or activated sludge organisms.

18.3

Unit Operation	Observation	Cause	Corrective Action
Equalization Tanks Receive, store and mix influent waste water	pH too low or erratic	Caustic feed inoperative	1. Repair caustic feed system 2. Refill caustic supply
		Influent water pH lower than design	1. Increase caustic flow 2. Correct at source
		Tank mixing equipment inoperative	1. Repair mixers
		pH probes dirty or out of calibration	1. Clean and recalibrate pH probe
	pH too high	Excess caustic feed	1. Reduce caustic feed rate
		Broken feed system	1. Diagnose and repair caustic feed system
		Influent pH higher than design	1. Correct at source 2. Revise system to feed acid
		pH probes dirty or out of calibration	1. Clean and recalibrate pH probes
	Floating oil	Excess oil causing oil separation	See section 18.2
	Tank contents	Influent flow rate reduced	1. Check influent piping system 2. Decrease flow rate to treatment plant[a]

a. Monitor phenol loads to assure adequate food to activated sludge organisms.

Unit Operation	Observation	Cause	Corrective Action
		18.4	
Mixer Chamber No. 1 Sodium sulfide feed	High sulfide odor	Low pH in equalization tank	1. Check pH and caustic feed in equalization tank
		Sulfide feed too high	1. Correct sulfide feed rate 2. Check hexavalent chromium concentration
		18.5	
Mixer Chamber No. 2 Ferrous sulfate feed	Solution light colored or yellow in chamber	Low ferrous sulfate feed	1. Check feed pump 2. Check waste water flow rate 3. Check hexavalent chromium concentration
	Solution rust orange colored	High ferrous sulfate feed	1. Check ferrous sulfate feed ratio 2. Check sodium sulfide feed
pH	pH <7.2	High sulfuric acid feed	1. Calibrate pH probe in Mixer No. 2 2. Check sulfuric acid feed pump
	pH >7.5	Low sulfuric acid feed	1. Calibrate pH probe in Mixer No. 2 2. Check sulfuric acid feed pump
		High sulfide feed	1. Check feed pump 2. Check feed ratio

Unit Operation	Observation	Cause	Corrective Action
		18.6	
Mixer Chamber No. 3 Cationic polymer feed	Negative electrokinetic charge	Low polymer feed	1. Check polymer feed system 2. Check for plugging in streaming current detector feed line
		Low ferrous sulfate/sodium sulfide feed	1. Check feed ratios 2. Check hexavalent chromium concentration 3. Check flow rate
		18.7	
Solids Contact Clarifier	High Cr^{+6} in effluent	Chemical reduction process out of proper ranges: $S^{-2}:Fe^{+2}$ 1:30-1.70	1. Adjust sulfide and iron feed rates
		$Fe^{+2}:Cr^{+6}$ 3.00-0.85	1. Adjust iron feed rate
		pH 7.20-8.40	1. Adjust acid feed rate
	Fine black solids in effluent	Cationic polymer feed at wrong rate, improperly mixed, or too old	1. Adjust cationic polymer feed system
		Excessive turbulence causing particle break up	1. Reduce external sludge recirculation flow rate and/or open mixing chamber diffusion port gates
	Large black solids in effluent	Cationic polymer feed at wrong rate, improperly mixed, or too old	1. Adjust cationic polymer feed system

Unit Operation	Observation	Cause	Corrective Action
		18.7 (continued)	
		Anionic polymer fed at wrong rate, improperly mixed, or too old	1. Adjust anionic polymer feed system
		Insufficient sludge bed depth	1. Increase external return sludge flow rate and/or decrease sludge wasting rate
		Sludge depth too high	1. Increase sludge wasting rate
	Black colored effluent water	pH too high	1. Adjust acid feed rate
		Sulfide too high	1. Adjust sulfide feed rate
		18.8	
Softener Basins Surge basins used for supplemental solids separation	Excess turbidity	Solids contact clarifier performing at reduced efficiency	1. See Section 18.7
	Excess solids or high blow down frequency on solids	Solids carryover from solids contact clarifier	1. See Section 18.7
	Solids buildup in tanks	Broken flight conveyor	1. Repair mechanism

Unit Operation	Observation	Cause	Corrective Action
		18.9	
Activated Sludge Aeration Basins	Dark grey or black color (low D.O. conc.)	Insufficient air	1. Increased airflow rate
	Unusual color	New waste discharge	1. Locate and eliminate discharge
	Uneven turbulence	Clogged diffusers	1. Drain tank, clean diffusers
		Broken diffusers or holes in piping	1. Drain tank, repair or replace damaged diffusers or piping
	Excessive billowing white foam	Sludge age too low	1. Increase RAS and/or decrease WAS
	Thick scummy dark tan foam	Over oxidized sludge	1. Decrease RAS and/or increase WAS
Activated Sludge Final Clarifiers	Sludge bulking (very high and increasing SVI)	Filamentous microorganisms	1. Chemical treatment
			2. Increase sludge age by increasing RAS and/or decreasing WAS
			3. Nutrient addition
			4. Increased airflow rate
	Deflocculation (particle break-up) (SVI increase over a couple of days)	Toxic or acid wastes	1. Identify and eliminate discharge
		Anaerobic condition in the aeration basins	1. Increase the airflow rate

Unit Operation	Observation	Cause	Corrective Action
		18.9 (continued)	
		Overloading the aeration basins	1. Reduce waste strength and/or flow rate
			2. Increase capacity of aeration basins
		Insufficient nitrogen or phosphorus	1. Add nutrients
Activated Sludge Final Clarifiers	Deflocculation (particle break-up)	Excessive turbulence in the aeration basins	1. Decrease airflow rate in aeration basin
			2. Decrease throttling of RAS valves
			3. Utilize slower speed RAS pumps
			4. Utilize larger diameter RAS piping
	Clumping, ashing and rising sludge	Anaerobic sludge or denitrification of sludge	1. Reduce sludge storage in clarifiers by increasing RAS and/or increasing WAS
			2. Reduce flow rate into offending clarifier increasing flow rate into other clarifier
			3. Increase airflow rate
	Straggler Floc	Sludge age too low	1. Increase RAS and/or decrease WAS
	Pin Floc	Sludge age too high	1. Decrease RAS and/or increase WAS
		Sludge over oxidized	1. Decrease airflow rate
		Turbulence too great in the aeration basin	1. Decrease airflow rate in aeration basins

Unit Operation	Observation	Cause	Corrective Action
		18.9 (continued)	
			2. Decrease throttling of RAS valves
			3. Utilize slower speed RAS pumps
			4. Utilize larger diameter RAS piping
	Incompletely oxidized effluent	Increased organic concentration	1. Increase airflow rate and increase RAS and/or decrease WAS
		Increased organic and hydraulic load	1. Increase airflow rate and increase RAS and/or decrease WAS
		18.10	
Chlorination	High effluent COD	1. Low Chlorine dosage rate	1. Increase chlorine feed rate. 2. Repair malfunctioning chlorinator 3. Increase chlorinator capacity. 4. Replace empty chlorine cylinder
		2. Short circuiting through chlorine contact basin.	1. Repair tank baffles 2. Clean out accumulated tank sediment
	Excessive chlorine use	1. Malfunctioning Chlorinator	1. Repair chlorinator

Unit Operation	Observation	Cause	Corrective Action
		18.11	
Pressure Filters	High effluent SS or turbidity.	1. Filters need cleaning	1. Backwash filters 2. Increase length of backwash.
		2. Malfunctioning surface wash	1. Repair surface wash
		3. Malfunctioning backwash pump	1. Repair backwash pump
		4. Insufficient backwash flowrate	1. Increase backwash flowrate
		5. Incorrect polymer dosage	1. Evaluate different polymer dosage rates
		6. High pressure alarm setpoint too high	1. Reset high pressure alarm setpoint lower
		7. Loss of filter media	1. Replace lost media and reduce BW flowrates
	Short filter runs	1. Insufficient BW flowrate	1. Increase BW flowrate
		2. Malfunctioning surface wash	1. Repair surface wash
		3. Malfunctioning BW pump	1. Repair BW pump
		4. Incorrect polymer dosage	1. Evaluate different polymer dosages
		5. Unusually high influent SS	1. Correct upstream treatment processes
		18.12	
Reclaimed Water Storage Tank	Excessive flowrate from the overflow pipe	1. Effluent value closed	1. Open the effluent valve.
		2. Malfunctioning effluent valve	1. Repair the effluent valve
		3. Clogged pipeline or valve	1. Locate and remove obstruction

Unit Operation	Observation	Cause	Corrective Action
		18.12 (continued)	
	Inability to increase water level in the storage tank	1. Influent valve closed	1. Open the influent valve
		2. Malfunctioning influent valve	1. Repair the influent valve
		3. Clogged pipeline or valve	1. Locate and remove obstruction
	Poor quality water coming from the storage tank	1. Problems with the operation of upstream treatment processes	1. Determine which process or processes are not performing adequately, determine and correct the cause. Refer to section 18, 15, IWWTP effluent
		8.13	
Gravity Sludge Thickener	Excessive SS in effluent.	1. High instantaneous flowrates	1. Decrease the flowrate of the sludge transfers into the thickener
		2. Excessively long durations of sludge transfers	1. Transfer sludge more frequently for shorter periods
		3. Sludge level too high in the thickener	1. Transfer sludge from the thickener to the sludge holding tank
	Excessively thin sludge being transferred to the filter holding tank	1. Sludge level too low in the thickener	1. Allow more sludge to accumulate in the thickener before tranferring to the sludge filter holding tank
		2. Sludge transfer rate too high causing "post holing" through the sludge blanket	1. Decrease the flowrate at which the sludge is transferred from the thickener

Unit Operation	Observation	Cause	Corrective Action
		18.13 (continued)	
	High thickener drive torque	1. Sludge level too high	1. Transfer sludge to the sludge filter holding tank
		2. Sludge too thick	1. Decrease the polymer dosage rates in the SCC
		3. Obstruction in the thickener tank	1. Drain the thickener tank, find the obstruction and remove it
		18.14	
Sludge Dewatering Filter	Sludge cake will not discharge	1. Too much flocculating chemical	1. Reduce the chemical dosage rate
		2. Sludge cake too wet	1. Slow filter speed 2. Increase vacuum: a. Adjust vacuum pump b. Adjust sludge submergence c. Eliminate leaks in the vacuum piping d. Repair filtrate pump check valve 3. Increase sludge homogeneity: a. Increase slurry mixing b. Install baffles in feed trough 4. Eliminate septic sludge: a. Decrease sludge holding time
	Sludge cake will not form	1. Cloth binding	1. Improve filter cloth washing: a. Clean clogged water nozzles b. Increase water pressure

Unit Operation	Observation	Cause	Corrective Action
		18.15	
IWWTP Effluent	High COD	1. Filters are not removing suspended solids	Refer to Section 18.11
		2. Final clarifiers are carrying over excess solids	Refer to Section 18.9
		3. Activated sludge is not degrading organics	Refer to Section 18.9
		4. Chlorine contact is insufficient	Refer to Section 18.10
	High Phenol	1. Activated sludge is not degrading the phenols	Refer to Section 18.9
		2. High influent phenol	Refer to Section 18.1
	High Cyanide	1. High influent cyanide	1. Locate and eliminate cyanide discharge. 2. Destroy cyanide in equalizatin tank
	High Metals (Cr, Ni, Cd, Cu, Pb, and Zn)	1. Insufficient treatment chemicals	Refer to Sections 18.4, 18.5, and 18.6
		2. SCC is carrying over solids	Refer to Section 18.7
		3. Hexavalent chromium is not being reduced	Refer to Sections 18.4, 18.5, and 18.6
		4. Insufficient cationic polymer feed	Refer to Section 18.6

Unit Operation	Observation	Cause	Corrective Action
		18.15 (continued)	
		5. Insufficient anionic polymer feed	Refer to Section 18.7
	High Suspended Solids	1. Filters are not removing suspended solids	Refer to Section 18.11
		2. SCC is carrying over solids	Refer to Section 18.7
		3. Final clarifiers are carrying over excess solids	Refer to Section 18.9
	High Hexavalent Chrome	1. Insufficient treatment chemicals	Refer to Sections 18.4 and 18.5
		2. Incorrect influent hexavalent chromium	Refer to Section 18.3
	High Oil and Greases	1. Oil separator is not removing oils and greases	Refer to Section 18.2
	Foaming at Effluent	1. Insufficient defoamer is being added	Refer to Section 18.9

SECTION VI

MAINTENANCE SCHEDULE

The following maintenance schedule applies to the new equipment added with the sulfide/sulfate metals reduction process. Existing operations manuals should be referred to for requirements on previously installed equipment.

MAINTENANCE SCHEDULE

Equipment	Shift	Week	Month	Other
Blending Tank Controls				
o Timer-timed on/ Manual on-off	(Manual not yet available)			
Caustic Feed at Equilization Tank				
o 20 GPH Pulse Diaphragm	(No Maintenance specified)			
o Pump				
o Timer-Timed on/ Manual on-off	(Manual not yet available)			
o Building Heater	(Manual not yet available)			
Sodium Sulfide Feed Chamber #1				
o Tank 6000 gal liquid				Annual inspection
o 1-1/2 HP Mixer			lub brgs. quarterly	Change grease annually
o Tank-1000 gal dry/liquid mix				Annual inspection and cleanup
o 1-1/2 HP Mixer				Change grease annually lub. brgs. quarterly

Equipment	Maintenance Frequency: Shift	Week	Month	Other
Sodium Sulfide Feed Chamber #1				
o 2-20 GPH Pulse Diaphragm Pump	(No maintenance specified)			
o Pulse Control Timer	(No maintenance specified)			
o Building Timer	(No maintenance specified)			
Ferrous Sulfate Feed Chamber #2				
o Tank-6000 gal-liquid				Annual inspection and cleanup
o 1-1/2 HP Mixer				Change grease annually, lub. brgs. quarter
o 2-20 GPH Pulse Diaphragm Pump	(No maintenance specified)			
o Pulse Control Timer	(No maintenance specified)			
pH Control Chamber #2				
o pH Transmitter to portable probe	Compare results			Calibrate every 6 months
o pH controller				Calibrate annually
o pH Recorder	(No maintenance specified)			
o Pulse Diaphragm Pumps (2)	(No maintenance specified)			
Polymer Feed Chamber #3				
o 2000 gal Tank				
o Betz Feeder (1195 Polymer)				Annual Inspect/Clean

Equipment	Maintenance Frequency: Shift	Week	Month	Other
Streaming Current Detector				
o 5 gpm sample pump				
o Streaming Current Meter	Cell	Clean[a]	Yearly	Replace plugger assembly
o Recorder	(No maintenance specified)			
Polymer Feed-Solids Contact Clarifier				
Betz Feeder (1120 Polymer)				
Recycle Pumps-Solids Contact Clarifier				
o ____gpm Pumps (2)				
o ____HP Motors (2)				
o Motor Controls	(No maintenance specified)			
o Timers	(No Maintenance specified)			
Flow Process Monitors				
o Hach Continuous Flow Turbidimeter			-Standardize	-Calibrate every 4 months
o Scientific Instruments Hexavalent Chrome Continuous Flow Analyzer	-air segmentation	-Inspect tubing for -leakage -cleanliness	-Drain and flush body as required by visual inspection -Clean underside of pump platen filters	Quarterly -Clean source lamp -Check for lamp blacking -Clean interference

Equipment	Maintenance Frequency			
	Shift	Week	Month	Other
Flow Process Monitors				
	Calibrate	-Clean and flush sample line and waste tube -Rinse sample tube -Replace reagents	Yearly -Replace waste tube from sample flow cell	

a. Adjust frequency as needed to prevent meter drift.

ABBREVIATIONS AND ACRONYMS

AFB	Air Force Base
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DFA	Continuous Flow Analyzer
DO	Dissolved Oxygen
E Tank	Equalization Tank
EPA	Environmental Protection Agency
F	Food
F/M	Food to Mass Ratio
FIC	Flow Indicator Controller
gph	Gallons per hour
gpm	Gallons per minute
HP	Horsepower
IWTP	Industrial Wastewater Treatment Plant
LIC	Level Indicator Controller
M	Mass
MCRT	Mean Cell Residence Time
mg/L	Milligrams per liter
MGD	Million Gallons Per Day
mL	Milliliter
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Units
P&I	Piping and Instrumentation
RAS	Return Activated Sludge
SCC	Solids Contract Clarifier
SCFM	Standard Cubic Feet Per Minute
SS	Suspended Solids
SVI	Sludge Volume Index
TDH	Total Dynamic Head
WAS	Waste Activated Sludge